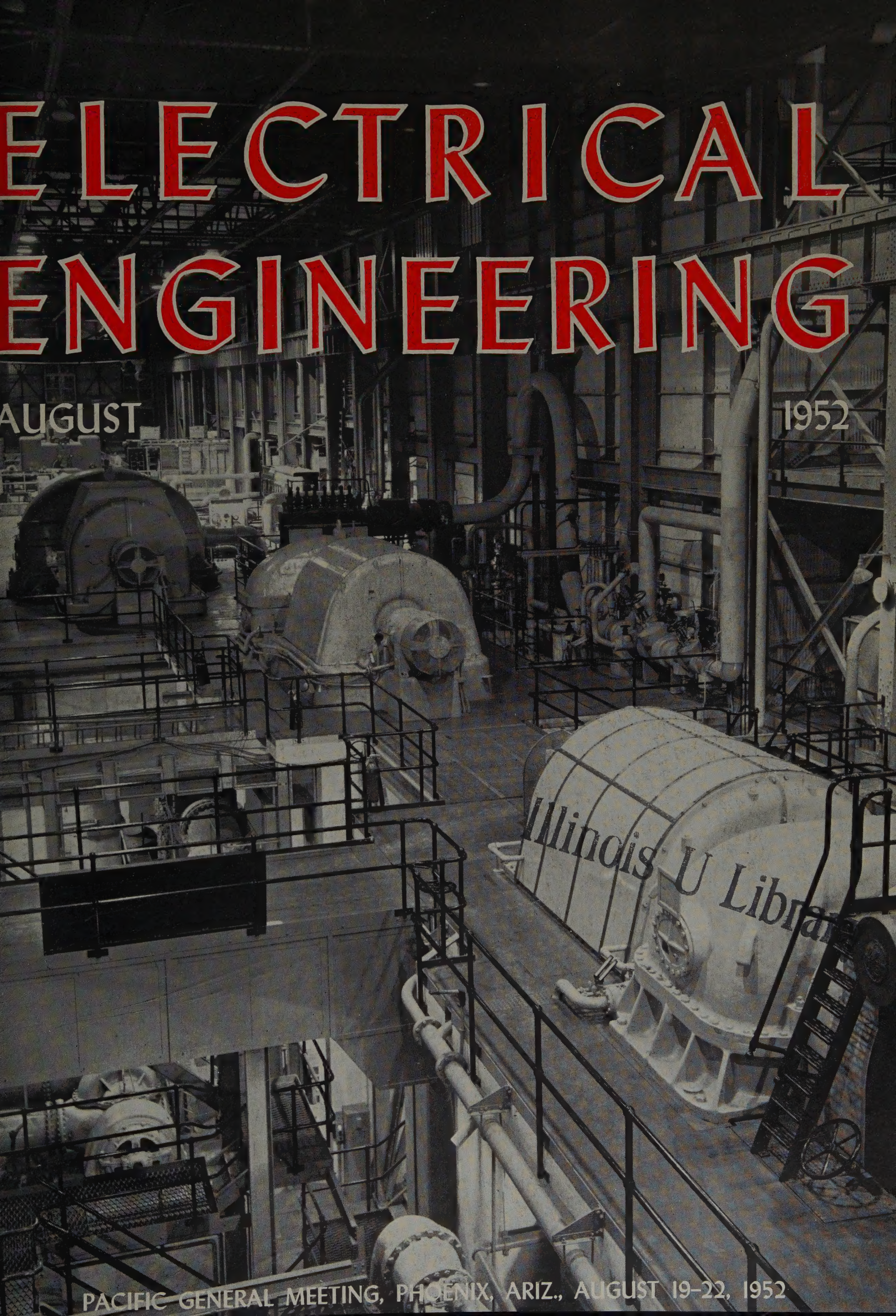
ELECTRICAL ENGINEERING

AUGUST 1952



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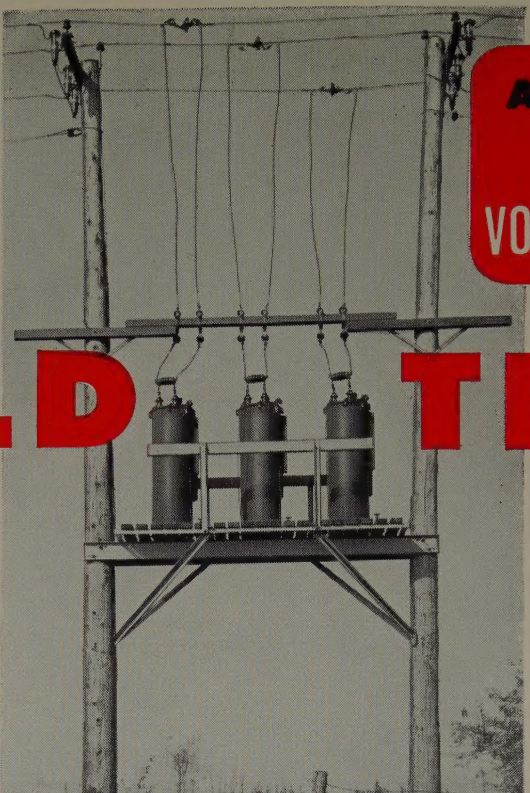

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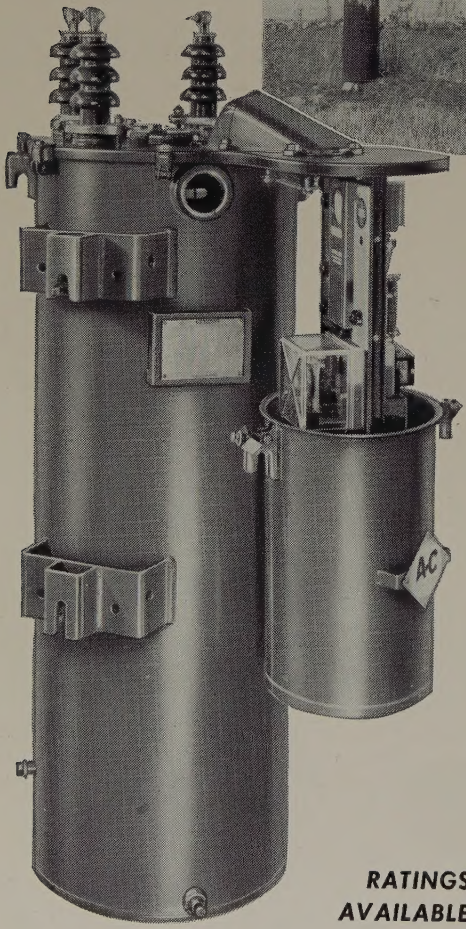

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AUGUST
1952

The Cover: The Arizona Public Service Company's 155,000-kw steam-electric station, located 5 miles west of Phoenix. It is designed for natural gas and oil fuel.
Randsdell photo

Our Achievements .... F. O. McMillan . . . 677
The Whirlwind I Computer .... R. R. Everett . . . 681
New Pulse Klystron Amplifier for the 960–1,215-Megacycle Region .... Carol Veronda . . . 686
Investment Costs for Use in the Economic Comparison of Alternative Facilities .... F. L. Lawton . . . 691
Arthur Elmer Silver—Lamme Medalist for 1951
The Establishment of the Medal .... A. H. Kehoe . . . 698
Career of the Medalist .... Clay C. Boswell . . . 698
Pioneering and Development of Electrical Service to the Farm .... A. E. Silver . . . 700
Short-Circuiting Techniques for Deactivating a Faulty Aircraft Generator .... Oscar Markowitz, J. W. Pobst . . . 703
Broad-Band Coupling Unit for Power-Line Carrier With Associated Potential Device .... J. A. Doremus, R. P. Crow, W. H. Freeman . . . 707
Polyethylene Terephthalate as a Capacitor Dielectric .... M. C. Wooley, G. T. Kohman, William T. McMahon . . . 715
Loom Desynchronizing .... F. D. Snyder . . . 718
The 3-Gun Shadow-Mask Color Kinescope .... H. B. Law . . . 723
Reliability of 28-Volt D-C Aircraft Distribution Systems .... K. W. Carlson, E. S. Sherrard . . . 731
Bus-Bar Design for High-Frequency Induction Heating .... J. W. Williamson . . . 736
Power System Stability Criteria for Design .... W. A. Morgan . . . 740
The Notched-Disk Memory .... Jacob Rabinow . . . 745

TECHNICAL PAPER DIGESTS

The Impulse Generator and Its Uses .... J. H. Chiles, Jr., W. L. Teague . . . 690
Load Pickup After Extended Outage .... A. W. Edwards, L. V. Chabala . . . 697
Impulse Corona Detection and Measurement .... J. H. Hagenguth, T. W. Liao . . . 706
Transmission-Line Capacitance and Voltage Gradient .... H. B. Dwight, F. E. Scheidler . . . 714
Circuit Breakers in the Bonneville Power System .... O. A. Demuth, Alexander Dovjikov . . . 721
A Compact, Inexpensive A-C Network Analyzer .. E. W. Kimbark, J. H. Starr, J. E. Van Ness . . . 722
A Series Magnetic Amplifier With Inductive Loading .... T. G. Wilson . . . 729
The Calculation of the Magnetizing Force .... A. A. Halacsy . . . 730

MISCELLANEOUS SHORT ITEMS: Westinghouse Completes Sound Laboratory for Noise Study, 696; Model Tests of Turbine for Reclamation Project Are Completed, 713; Determining the Rate at Which Human Blood Cells Absorb an Isotope, 735; Electromagnetic Pump Moves Molten Metals at High-Temperatures, 744

Institute Activities 750
AIEE Personalities, 763; Obituary, 764; Membership, 765

Amendments to AIEE Constitution 766

Of Current Interest 768
New Books, 772

Industrial Notes 18A
New Products, 28A; Trade Literature, 50A

Index to Advertisers 84A

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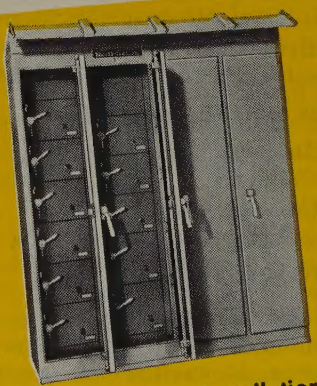

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HIGHLIGHTS........

Bimonthly Publications. As previously announced, three new bimonthly publications have been issued in place of the former AIEE *Proceedings* which have been discontinued. These new bimonthly publications contain all of the formally reviewed and approved papers (numbered papers exclusive of numbered ACO papers) which have been presented at the General and District meetings. The publications are titled as follows:

Communication and Electronics
Applications and Industry
Power Apparatus and Systems

Each of the publications is on an annual subscription basis; members may elect to receive in consideration of payment of dues without additional charge one of the three publications. Additional publications may be obtained by members at an annual subscription price of $2.50 each. A subscription card was sent to the membership in March for this purpose. Nonmembers may subscribe to any of the three publications on an advance annual subscription basis of $5.00 each (plus 50 cents extra for foreign postage payable in advance in New York exchange). A discount of 25 per cent will be allowed to college and public libraries. Publishers and subscription agencies may be allowed a discount of 15 per cent. Single copies may be obtained when available at $1.00 each.

Our Achievements. At the close of his year of AIEE presidency, F. O. McMillan reports on the state of the Institute. Much has been accomplished, but much still remains to be done, and the outgoing president solicits continued co-operation and support from the Institute's officers and members for his successor, D. A. Quarles (*pages 677–80*).

The Lamme Medal. The Lamme Medal for 1951 was presented to Arthur E. Silver during ceremonies at the recent Summer General Meeting in Minneapolis.

Included in this issue are the full texts of the presentation and acceptance addresses (*pages 698–702*).

News Index

Institute Activities................750

Pacific General Meeting....................750
Future AIEE Meetings....................750
Centennial of Engineering....................752
Summer General Meeting Held....................754
Committee Activities....................762
AIEE Personalities....................763
Obituary....................764
Membership....................765

Of Current Interest................768

Magnetronic Reservisor....................768
Most Powerful Human Centrifuge....................769
Future Meetings of Other Societies....................769
New Books....................772

Whirlwind I Computer. This article gives a description of the computer as it is now and discusses the changes to be incorporated within the year to improve its performance (*pages 681–6*).

New Pulse Klystron Amplifier. This tube has a peak power output of from 4 to 30 kw at a 25-per-cent efficiency over the 960–1,215-megacycle range. Its radio-frequency power gain is from 300 to 2,500 when synchronously tuned. Its design and characteristics are discussed (*pages 686–9*).

Investment Costs in Economic Comparison of Facilities. The necessity for basing these costs on estimates is emphasized. The need for the assistance of hydraulic-model tests, network-analyzer investigations, and other aids to conversion of engineering concepts into dollar estimates is pointed out. The widely varying practices in making estimates is presented, and suggestions to improve the situation offered (*pages 691–6*).

Short-Circuiting Techniques for Aircraft Generators. Presently available equipment and circuits do not provide assurance that the terminal voltage of a self-excited d-c generator after a full-field short-circuiting fault will be reduced to zero or, after a generator feeder fault, the current output of the machine will be reduced to zero. The results of short-circuiting tests are given in this article (*pages 703–05*).

Broad-Band Coupling Unit. Field tests have proved that this aperiodic coupling unit and potential device make it possible to space transmitter frequencies more closely than was possible with the older tuning system, and without the usual narrowing of the passband at the lower end of the spectrum. Another advantage is that tuning up a unit is very simple as there is only one inductance to adjust (*pages 707–13*).

Polyethylene Terephthalate or Mylar. This new plastic dielectric in film form shows great promise for use in electrical capacitor manufacture. Its properties are superior to those of paper dielectrics in several respects (*pages 715–17*).

Loom Desynchronizing. When the lays of several rows of looms operate in synchronism, their combined forces act on the building in the same way as soldiers marching in step act on a bridge. To keep the looms' lays out of step is the object of the electrical scheme presented (*pages 718–20*).

The 3-Gun Shadow-Mask Kinescope. The kinescope well may be considered as the heart of any television receiver because upon it are built the end results of the whole system. A great amount of research has gone into the cathode-ray tube for reproducing pictures in their natural colors and the progress made in the development of this particular tube illustrates well the ingenuity of those men responsible for the results achieved (*pages 723–8*).

28-Volt D-C Aircraft Distribution System Reliability. The protection of the typical setup in this distribution system for large multiengine aircraft is discussed. This article points up how relatively minor modifications in bus arrangement can increase system reliability considerably (*pages 731–5*).

Notched-Disk Memory. This new magnetic information-storage device combines the advantages of large storage capacity with rapidity of access. Magnetic pulses are stored on both sides of thin notched metal disks. These disks are aligned with the planes of the disks parallel to each other and perpendicular to the toroid-shaped ring in which they are mounted. Tests have demonstrated that data can be reached in about half a second (*pages 745–9*).

Bus-Bar Design for High-Frequency Induction Heating. Information not previously available to users of induction heating equipment is provided. It includes tabular data on the more common frequencies, but also equations applicable to a much broader range of frequencies (*pages 736–9*).

Power System Stability Criteria for Design. The author poses many questions concerning the use of specific criteria, and then presents data obtained in Bureau of Reclamation studies to show how these questions can be answered under certain conditions (*pages 740–4*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

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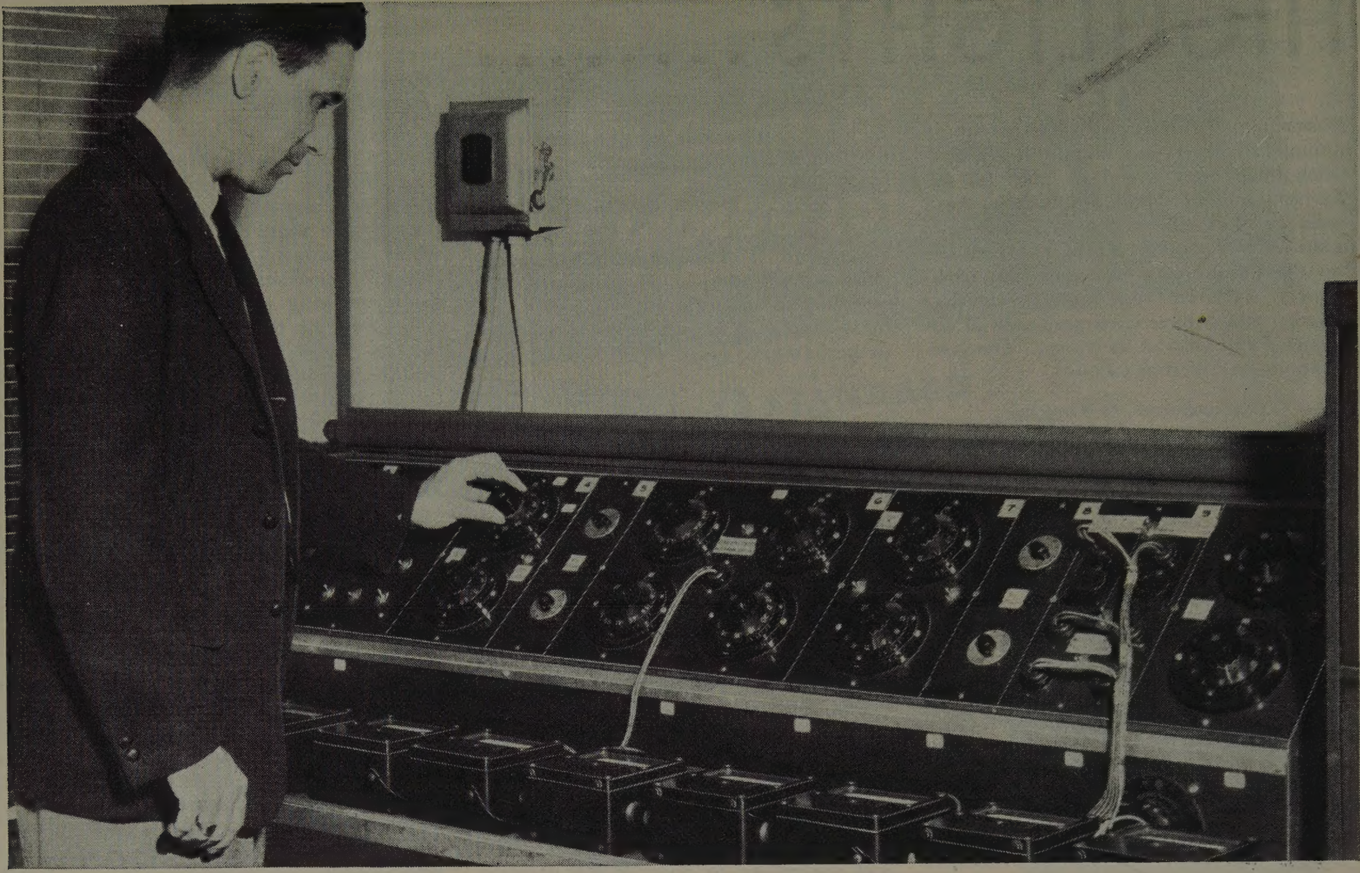

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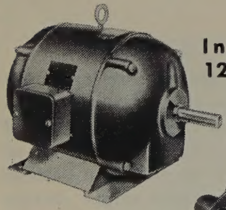

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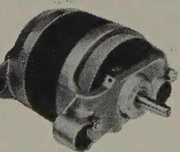
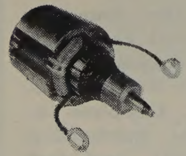


Fractionals—from 1/200 horsepower



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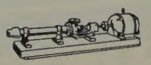

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Our Achievements

F. O. McMILLAN
FELLOW AIEE

Professor McMillan herein reports on the progress of the Institute during his administration as President. In the course of that year, membership increased by more than 13 per cent, with a subsequent increase in Section and committee activities, a new publications policy was formulated, and plans for a new Engineering Societies Center were considered.

ON THE OCCASION of being notified of my election to the presidency of the AIEE last June and upon receiving the President's badge at the hands of President Le Clair, I ventured to suggest some objectives for 1951–52 (*EE, Aug '51, pp 657–9*). It, therefore, appears appropriate, as we approach the close of this administrative year, that I should report on the state of the Institute.

At the time I set down some objectives a year ago, it was fully realized that the course of the society already had been set toward many of the objectives by previous administrations. Steering the course of a great society such as the Institute is like being at the helm of a great vessel; the course must be charted long in advance, because she can not and will not respond to every sudden movement of the rudder. It is good that this is so because we should be steering toward great achievements and not chasing after every whim and fancy that for the moment appears attractive but, in the end, will compromise and jeopardize our position.

GROWTH

THE GROWTH OF the Institute has been phenomenal in the past decade. Our membership has grown from 18,944 corporate members on May 1, 1942, to 43,267 on June 1, 1952, an increase of 24,323 members, or 128 per cent. In the past year the membership has increased 5,200, or more than 13 per cent. Student membership grew from 5,962 on May 1, 1942, to 8,857 on April 30, 1952, an increase of 2,895, or 48.5 per cent. It should be pointed out that our Student membership passed through a maximum of 20,668 on May 1, 1950, and has been declining rapidly since that time due to the general decrease in college enrollment and engineering student enrollment in particular. We may expect the decrease in electrical engineering graduates to be reflected by a sharp decrease in the rate of growth of our corporate membership.

In 1942 we had 42 Sections and in 1952 we have 95 Sections and 50 Subsections. In 1942 we had 124 Student Branches and in 1952 we have 132.

The rapid growth in membership, Sections, and Subsections has made it necessary to make adjustments in both organization and procedures to provide service for the increased numbers that must be served. This has been accomplished by several changes and some of the notable ones should be mentioned. During the past 2 years the major responsibility of visiting Sections, Subsections, and Student Branches has been delegated to the Vice-Presidents and in some of the larger Districts they have called upon the Directors to assist. The Mid-West or Fall General Meeting was instituted in 1947 to provide an additional annual technical meeting in an area where the membership is large and there is need for an outlet for technical papers and conferences. District meetings have increased in size and importance. An increase in the number of technical groups in the Sections and Subsections has made it possible to serve many more members with programs that are of particular interest to them. The special technical conferences that were inaugurated in 1948 have been very successful in providing a medium for the dissemination of information in new or highly specialized fields. These conferences have been financially self-supporting.

COMMITTEES

A LARGE TECHNICAL SOCIETY such as the AIEE requires a multitude of committees to carry on the work and activities of the society. At present we have 17 general committees, 11 professional committees, 262 technical committees and subcommittees in five technical divisions. We have members on 8 joint subcommittees with other professional societies and members serving on 34 other groups of various kinds. These constitute a total of 332 committees, subcommittees, and groups of a continuing character on which our members serve.

In 1947 a plan was conceived for organizing the committees of the Institute in related groups or divisions for purposes of administration. This plan is a part of the program of improving the efficiency of operation by decentralization and getting the administration as close to the working units as practical. The divisional plan of operation is now established and working well. As indicated in enumerating the various committees, we have one professional division and five technical divisions. The technical divisions consist of a Communication Division, a General Applications Division, an Industry Division, a Power Division, and a Science and Electronics Division.

Full text of an address presented at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952.

F. O. McMillan, AIEE past president (1951–52), is Head of the Department of Electrical Engineering, Oregon State College, Corvallis, Oreg.

Based upon the experience with divisional operation to date and the recommendations of the Professional Division Advisory Committee and the Planning and Co-ordination Committee, the Board of Directors voted to discontinue the Professional Division Advisory Committee at the end of the present administrative year and merge the Technical Program Committee and Technical Advisory Committee into one committee. The combined committee will be the Committee on Technical Operations.

The divisions and committees within the divisions are now sufficiently well established and the scopes well enough defined by experience to justify redrafting the Bylaws to implement and regularize the divisional system of operation. The latter has been one of the major projects of the Committee on Constitution and Bylaws under the chairmanship of Director Frank R. Benedict.

PUBLICATIONS

Publications are a perennial problem that probably always will be with us, but thanks to the valiant efforts of the Publication Committee under the able chairmanship of Dr. Karl B. McEachron, the splendid co-operation of Editor Charles S. Rich and his staff, and many others, we appear nearer a happy solution of the publication problem than at any time in recent years. This is no mean achievement because our publication requirements are complex and difficult due to the wide range of interests found among our members and the consequent variety of articles and papers they contribute and wish to read.

Electrical Engineering has maintained a high standard of publication by publishing only papers and articles that have not been published elsewhere and by careful selection of subject matter that is within the range of interest of the membership. This policy has met with general approval, hence the monthly magazine will be continued much as it is at present.

The changes in publication policy have to do with the *Proceedings* and *Transactions*. The Publication Committee submitted a questionnaire to our membership designed to furnish information and to serve as a guide to publication policy.

Over 19,000 replies were received in response to the questionnaire and these were carefully analyzed. The analysis shows that our members strongly favor divisional publications for the *Proceedings* and that they want the papers in their particular field of interest to come to them automatically without marking and mailing a request as required at present.

Based upon the results of the survey and a careful analysis of publication problems, the Publication Committee and the Publications Department developed a plan for publishing the technical papers and the discussions of them in three related groups which has been approved by the Board of Directors. These publications will be: *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*. These three publications will supersede the present *Proceedings* and will be issued bimonthly beginning in July. Happily, a cost analysis indicates that the new plan will cost less than the present method of distributing the *Proceedings*. *Communications and Electronics* and *Applications and Industry* are to appear in July and *Power Apparatus and Systems* in August and they will be published in that order in successive months. Each member may elect to receive any one of the three publications without additional charge and may subscribe for additional publications at an annual subscription rate of $2.50 per publication. The annual *Transactions* will be in three parts: Part 1, "Communication and Electronics"; Part 2, "Applications and Industry"; and Part 3, "Power Apparatus and Systems." Members may purchase the *Transactions* at $3.00 per part, or all three parts for $6.00. The *Transactions* published in this form will be made available during the early part of 1953.

STUDENT ACTIVITIES

Since President Charles F. Scott a half century ago (1902–03) conceived the idea of organizing Student Branches and later of creating the grade of Student member, the engineering societies have become more and more dependent upon engineering graduates for new members. It is, fitting therefore, that we should be concerned about maintaining a sound student program.

While a badge does not make an engineer it does mark him, therefore, it was thought desirable to encourage Student members to wear the AIEE Student member badge. To this end the Board of Directors, at the August 23, 1951, meeting, authorized supplying a badge, without additional charge, to Student members upon request, as well as supplying a badge to new Student members, when one is requested on the Student membership application form. This plan apparently has worked well; I am sure I have seen more students wearing the badge this year than ever before.

Our greatest source of membership applications during the years 1950 and 1951 has been from the transfer of graduate Student members; in fact, during each of these years the applications from this source numbered roughly twice those applying from all other sources. The rapid decline in the number of electrical engineering graduates since 1950 will dry up our greatest source of membership sources quickly unless we take unusual measures to prevent it. It is, therefore, important to maintain close contact with Student members during their first year after graduation and to encourage their transferring to the grade of Associate Membership without allowing the transfer privilege to lapse.

Vice-President Ferris W. Norris has proposed a card record system for maintaining Institute contact with individual Student members for the period immediately after graduation. This card system will maintain contact with all graduates who have accepted employment and have left records of the names and addresses of their employers with their college or university. To maintain this contact it is necessary to have the co-operation of the students, the Student Branch Counselors, national headquarters, the Section Secretaries, and the Section Membership Committees.

This Student member contact plan was put in effect this year with the enthusiastic support of Vice-President

C. S. Purnell, Chairman of the Sections Committee; J. C. Wood, Chairman of the Membership Committee; and Professor F. W. Tatum, Chairman of the Committee on Student Branches. Headquarters mailed thousands of the cards to the Counselors and great numbers of them have been completed and returned for sorting and forwarding to the Section Secretaries concerned. If the Norris plan proves as effective as it now promises, it surely will be continued in future years because it will supply the continuity of contact with graduates that has been needed.

In connection with the operation of Joint AIEE–Institute of Radio Engineers (IRE) Student Branches there have been, and in the future will be, problems that require special consideration and recommendations for their solution. A subcommittee of the AIEE Committee on Student Branches and the Education Committee of IRE was established last year to consider these problems. The scope of this subcommittee was limited and probably because of this limitation it did not function. At a meeting of the Joint AIEE-IRE Co-ordinating Committee, on May 15, 1952, it recommended that the responsibility of this subcommittee be increased to make it responsible for the effective and satisfactory operation of Joint AIEE-IRE Branches by recommendations through appropriate channels to the Boards of the two societies. The AIEE Board of Directors approved this recommendation on June 26 and the IRE Board will consider it at its meeting in September.

Something of the order of ten per cent of the Institute Members for Life elect to continue to pay their annual dues and these payments are accumulated in the Member-for-Life Fund. By action of the Board of Directors in 1945, "this fund is to be used only for such special purposes as will aid the objectives of the Institute, these purposes to be determined by a designated administrative committee." Each year from 1946 to 1951 inclusive, awards have been made to the winners of the District Branch paper prizes in five Districts. An award consists of the prevailing Institute mileage allowance from the winner's home town to the Summer General Meeting, plus a reasonable allowance per day for the official duration of the meeting. The winners of the awards present their papers on the technical program of the Summer General Meeting.

These prize awards have been available in the even-numbered Districts on the even-numbered years and in the odd-numbered Districts on the odd-numbered years. The awards have been very successful in stimulating interest in the preparation of student papers and in acquainting the award winners with the Institute and its members. However, it has been unfortunate for those students who have won the District Branch paper prizes on the years when their Districts were not eligible for the awards.

I am happy to announce that the committee administering the Member-for-Life Fund has found that the fund has grown to an amount that makes it possible to make awards available to all ten Districts each year and that all Student members who won District Branch paper prizes this year have had the opportunity to attend the Summer General Meeting with their expenses paid. On behalf of the Institute and especially our Student members I wish to express our sincere appreciation to the Members for Life whose voluntary continuation of payment of dues has made this magnificent contribution to the student program possible.

F. O. McMillan

ENGINEERING UNITY

THE EXPLORATORY GROUP to Consider The Increased Unity of the Engineering Profession submitted a second report in December 1951. This report proposed a unity organization along the general lines of Plan *A* of the plans designated as *A*, *B*, *C*, and *D*, in their first report issued in December 1950. You will recall that subsequent to the release of the December 1950 report by the Exploratory Group, Secretary Henline transmitted the report to all Section Secretaries with a request for an expression of preference for the various plans from each Section. The results of this survey were reported in a letter sent to the members of the Exploratory Group and the AIEE Board of Directors by Past-President Fairman on April 17, 1951.

The survey results showed that $7\frac{1}{2}$ Sections favored Plan *A*, none favored Plan *B*, $25\frac{1}{2}$ favored Plan *C*, 9 favored Plan *D*, 3 wanted no unity plan at all, and 2 had no preference. The half-Section figures come from one Section that reported the members were equally divided between Plans *A* and *C*.

Because of the strong sentiment in the Sections for Plan *C*, which provided for individual membership, and further because the plan proposed in the December 1951 report of the Exploratory Group is essentially Plan *A*, which was the third choice in the Section survey, the AIEE Board of Directors did not approve the proposal. The Board at its meeting on January 24, 1952, voted "that the plan not be accepted and that Past-President Le Clair continue efforts to bring about the formation of a unity organization based upon individual membership." The AIEE Board also proposed that a common questionnaire should be sent to all members of all participating societies. The latter proposal was rejected by the Engineers Joint Council at its meeting which took place on January 25, 1952.

Following the January Board meeting, the president of the Institute received a request to have the Board of Directors reconsider the action of January 24, 1952, on the proposed unity plan. The 1951 Report of the Exploratory Group, together with additional material, subsequently submitted, were considered on April 17, 1952, and the Board reaffirmed the action taken on January 24, 1952.

As we look back over the year I am sure all of us wish we might report greater progress toward a unity organization for engineers. However, as pointed out a year ago, the resolution of differences between long established societies may be a long-time project, therefore we should not despair of ultimately achieving unity in the engineering profession.

NEW ENGINEERING CENTER

It has been recognized for many years that the present Engineering Societies Building which was dedicated in April 1907, 45 years ago, is entirely inadequate to meet the needs of the four Founder Societies and their present associates. The building is not only inadequate but it has long been obsolete and is rapidly deteriorating to a condition that will require large sums of money for repair and maintenance. There is, therefore, great need for a new Engineering Societies Center that will be adequate to meet the headquarters needs, not only of the present occupants, but of all engineering societies.

The United Engineering Trustees (UET) for the past several years have been seeking possible donors who would contribute substantial amounts of money to finance a new headquarters building without success.

Recognizing the existing conditions and feeling that the Engineering Societies should take prompt action to raise the additional funds required, over and above the present assets of UET, President-elect Donald A. Quarles and Director Walter J. Barrett, two of our representatives on UET, were empowered by our Board of Directors on April 17, 1952, to prepare a resolution for transmittal to UET.

This resolution states, in part, that: " . . . it is the opinion of the Board of Directors of the American Institute of Electrical Engineers that the United Engineering Trustees should be urged to consider promptly, and submit to the other Founder Societies for their consideration, a plan for raising the additional funds required over and above the assets of United Engineering Trustees available for the purpose, by means of contributions from the reserve funds of the Founder Societies and of other engineering societies that might join in the project, with the understanding that if favorable consideration of this plan would make available a large part of the required additional funds, the balance would be solicited in the form of contributions from individual members of the interested societies or other sources . . . ."

This resolution is now before UET and is being submitted to the other engineering societies for their consideration and action.

EDISON MEDAL FUNDS

A deed of gift creating the Edison Medal was executed on the 11th day of February 1904, and since 1909 the medal has been awarded to 41 outstanding leaders in electrical engineering and related fields of science and industry by the Edison Medal Committee.

In recent years, due to increased costs and shrinkage of the returns from the trust fund, the medal has not been self-supporting. During this period the deficit has been made up by supplemental appropriations from Institute funds by the AIEE Board of Directors. For some time the Edison Medal Committee has been seeking additional funds to restore the medal to a self-supporting basis as intended by the donors who made the original deed of gift.

On behalf of Dr. J. F. Calvert, Chairman of the Edison Medal Committee and the members of that committee, I am happy to announce the gift of 150 shares of General Electric Company common stock to the AIEE by the General Electric Company. The income from this stock is to be used to supplement the income from the present Edison Medal Fund to the extent necessary to finance the awarding of the Edison Medal annually.

We are greatly indebted to the General Electric Company, the Edison Medal Committee, and all of those who have had a part in making it possible to restore the Edison Medal to a self-supporting basis.

ACKNOWLEDGMENTS

I would be negligent of my duty if I failed to acknowledge publicly and commend the officers and members of the Institute for the innumerable contributions you have made to maintain the high standards of our society and continue its upward progress to new heights of service and prestige during this year.

I have often said the Institute receives a class of service from its officers and members that money cannot buy; it is a service of love and devotion. You are all fully employed at your regular tasks and duties, you have no time to sell at any price, yet when the Institute calls for your services you give your best talents freely without money and without price. That is the spirit and type of service that has built our Institute and will carry it to greater heights. Fortunately, this kind of service and devotion also rewards the giver with a satisfaction and sense of achievement that exceeds any monetary reward no matter how great.

In conclusion I solicit from you the same cordial cooperation and support for President-elect Donald A. Quarles that you have given me this year. I could ask for nothing more. Your generous assistance has smoothed the way and made what could have been a very difficult task a pleasure and a great satisfaction.

The Whirlwind I Computer

R. R. EVERETT

The characteristics of this computer are presented along with contemplated improvements. A list of some of the actual problems handled is also included.

THE PROJECT Whirlwind is a high-speed computer activity sponsored at the Digital Computer Laboratory, formerly a part of the Servomechanisms Laboratory, of the Massachusetts Institute of Technology, by the Office of Naval Research and the United States Air Force. The project began in 1945 with the assignment of building a high-quality real-time aircraft simulator. Historically, the project always has been primarily interested in the fields of real-time simulation and control; but since about the beginning of 1947, most of its efforts have been devoted to the design and construction of the digital computer known as Whirlwind I (WWI). This computer has been in operation for over a year and an increasing proportion of project effort now is going into application studies.

Applications for digital computers are found in many branches of science, engineering, and business. Although any modern general-purpose digital computer can be applied to all these fields, a machine is generally designed to be most suited to some particular area. The WWI was designed for use in control and simulation work such as air traffic control, industrial process control, and aircraft simulation. This does not mean that the WWI will not be used on applications other than control. About one-half the available computing time for 1952 will be assigned to engineering and scientific calculation, including research in such uses supported by the Office of Naval Research through the Massachusetts Institute of Technology Committee on Machine Methods for Computation.

These control and simulation problems result in a specialized emphasis on computer design.

SHORT REGISTER LENGTH

CONTROL PROBLEMS are usually very simple mathematically. Furthermore, the computer is almost always part of a feedback rather than an open-ended system. Consequently, roundoff errors are seldom troublesome and the register length can be shortened to something comparable to the sensitivity of the physical quantities involved, perhaps five decimal places or less.

WWI has a register length of 16 binary digits including sign or about $4^1/_2$ decimals. The register length was chosen as the minimum that would provide a usable single-address order, in this case five binary digits for instruction and 11 binary digits for address. In a future machine we probably would increase this register length to 20 or 24 binary digits to get additional order flexibility; the increased numerical precision is less important.

For scientific and engineering calculation, greater than 16-digit precision is often required. There is available a set of multiple-length and floating point subroutines which make the use of greater precision very easy. It is true that these subroutines are slow, bringing effective machine speed down to about that obtained by acoustic memory machines. It is much more efficient to waste computing time occasionally this way than to waste continuously a large part of the storage and computing equipment of the machine by providing an unnecessarily long register.

HIGH OPERATING SPEED

CONTROL AND SIMULATION problems require very high speeds. The necessary calculations must be carried out in real time; the more complex the controlled system is, the faster the computer must be. There is no practical upper limit to the computing speed that could be used if available.

Where the problems are large enough, and these problems are, one high-speed machine is much better than two simpler machines of half the speed. Communication between machines presents many of the same problems that communication between human beings presents.

Great effort was put into WWI to obtain high speed. The target speed was 50,000 single-address operations per second, and all parts of the machine except storage meet this requirement. The actual WWI present operating speed of 20,000 single-address operations per second is on the lower edge of the desired speed range.

LARGE INTERNAL STORAGE

A LARGE AMOUNT OF high-speed internal storage is needed since it is not possible in general to use slow auxiliary storage because of the time factor. In many cases, a magnetic drum can be useful since its access time is short compared to the response times of real systems. Even with a drum there is considerable loss of computing and programming efficiency due to shuffling information back and forth between drum and computer.

Although designed for 2,048 registers of electrostatic storage, WWI was originally placed in operation with only 256 registers available. This number, while small, was adequate for much useful work. In September 1951, a second bank of new model storage tubes storing 1,024 spots per tube was installed. WWI has been operating reliably with these 1,024 registers since December 1951. The tubes in the first bank have been retired from service and will be replaced by new model tubes sometime in the near

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Revised text of a paper presented at the joint AIEE-Institute of Radio Engineers Computer Conference, Philadelphia, Pa., December 10–12, 1951.

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future. The resulting 2,048 registers will be on the lower end of what the project considers desirable. What the computer business needs, has needed, and probably always will need is a bigger, better, and faster storage device.

EXTREME RELIABILITY

In a system where much valuable property and perhaps many human lives are dependent on the proper operation of the computing equipment, failures must be very rare. Furthermore, checking alone, however complete is inadequate. It is not enough merely to know that the equipment has made an error. It is very unlikely that a man, presumably not too well suited to the work during normal conditions, can handle the situation in an emergency. Multiple machines with majority rule seem to be the best answer. Self-correcting machines are a possibility but appear to be too complicated to compete, especially as they provide no stand-by protection.

The characteristics of the WWI computer may be recapitulated as follows:

Register length	16 binary digits, parallel
Speed	20,000 single-address operations per second
Storage capacity	Originally 256 registers Presently 1,024 registers Target 2,048 registers
Order type	Single-address, one order per word
Numbers	Fixed point, 9's complement
Basic pulse repetition frequency	1 megacycle 2 megacycles, arithmetic element only
Tube count	5,000, mostly single pentodes
Crystal count	11,000

There are 32 possible operations, of which about 27 are assigned. They are of the usual types: addition, subtraction, multiplication, division, shifting by an arbitrary number of columns, transfer of all or parts of words, subprogram, and conditional subprogram. There are terminal equipment control orders and there are some special orders for facilitating double-length and floating-point operations.

One way to increase the effective speed of a machine is to provide built-in facilities for operations that occur frequently in the problems of interest. An example is an automatic co-ordinate transformation order. The addition of such facilities does not affect the general-purpose nature of the machine. The machine retains its old flexibility but becomes faster and more suited to a certain class of problems.

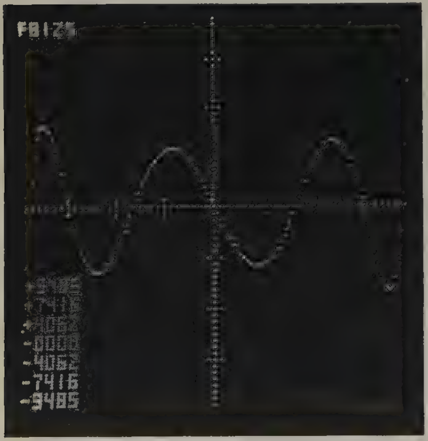

Figure 1. Sample computer output

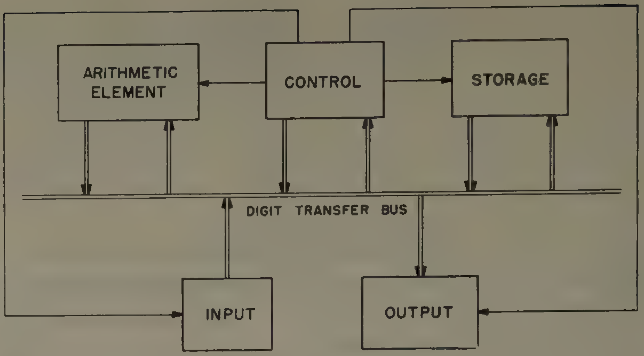

Figure 2. Simplified computer block diagram

From March 14, 1951, when we began to keep detailed records, until June 1, 1952, a total of 2,100 hours of computer time was scheduled for applications use. The machine was in successful operation for 85 per cent of this scheduled time. Total machine operating time during this period was 5,400 hours; the time not used for applications has been used for machine improvement, adding equipment, and preventive maintenance. WWI is now in operation about 150 hours a week.

Of the 2,100 hours available, 1,100 have been used by the scientific and engineering calculation group, the rest for control studies. The group has run a wide variety of problems, but has spent a large part of its time in training, setting up procedures, and preparing a library of subroutines.

A partial list of the actual problems carried out by the group includes:

1. An industrial production problem for the Harvard Economics School.
2. Magnetic flux density study for our magnetic storage work.
3. Oil reservoir depletion studies.
4. Ultrahigh-frequency television channel allocation investigation for DuMont.
5. Optical constants of thin metal films.
6. Computation of autocorrelation coefficients.
7. Tape generation for a digitally-controlled milling machine.

The scientific and engineering applications time on WWI has been organized in a manner patterned after that originated by Dr. Wilkes at Cambridge University. The group of programmers and mathematicians assigned to WWI assists users in setting up their own problems. Small problems requiring only a few seconds or minutes of computer time are encouraged. Applications time is assigned in 1-hour pieces two or three times a day. No program debugging is allowed on the machine. Program errors are deduced by the programmer from printed lists of results, storage contents, or order sequences as previously requested from the machine operator. The programmer then corrects his program which is rerun for him within a day or perhaps within a few hours.

Every effort is made to reduce the time-consuming job of printing tabulated results. In many cases a user desires large amounts of tabulated data only because he does not really know what answers he wants and so asks for everything. Such users are encouraged to ask only for pertinent results in the form of numbers or curves plotted by the machine on a cathode-ray tube and automatically photographed. If these results prove inadequate or the user gets a better idea of his needs, he is allowed to rerun his program, again asking only for what appear to be significant results. Figure 1 shows a sample curve plotted by the computing machine showing calibrated axes and decimal intercepts.

WWI SYSTEM LAYOUT

Figure 2 shows the major parts of any computer such as WWI. The major elements of the computer communicate with each other via a central bus system.

WWI is basically a simple, straightforward, standard machine of the all-parallel type. Unfortunately, the simple concept often becomes complicated in execution, and this is true here. WWI's control has been complicated by the decision to keep it completely flexible: the arithmetic element by the need for high speed, the storage by the use of electrostatic storage tubes, the terminal equipment by the diversity of input and output media needed.

CONTROLS

The WWI controls are divided into several parts, as shown in Figure 3.

The central control of the machine is the master source of control pulses. When necessary, the central control allows one of the other controls to function. In general there is no overlapping of control operation; except for terminal equipment control, only one of the controls is in operation at any one time.

Storage control generates the sequence of pulses and gates that operate the storage tubes. Central control instructs the storage control either to read or write.

Arithmetic control carries out the details of the more complex arithmetic operations such as multiplication and division. The setup of these operations plus the complete controlling of the simpler operations such as addition are carried out by central control.

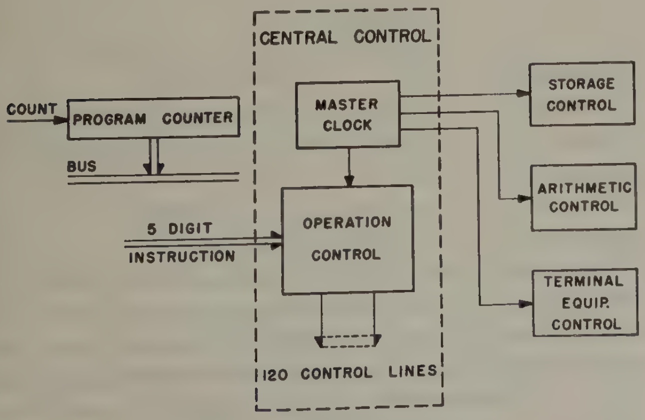

Figure 3. Controls of the WWI

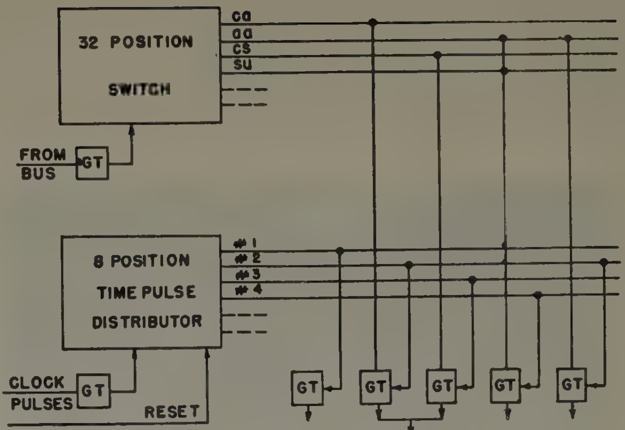

Figure 4. Operation control

Terminal equipment control generates the necessary control pulses, delay times, and interlocks for the various terminal equipment units.

The program counter which keeps track of the address of the next order to be carried out is considered as part of control. This is an 11-stage binary counter with provision for reading to the bus.

Most of the functions of these subsidiary controls could be combined with the central control. The major reason they are not is that they were designed at different times. The arithmetic element and its control came first, followed by central control. At the time central control was designed, the necessary characteristics of storage control were unknown. In fact, the machine was designed so that any parallel high-speed storage could be used. The form of terminal equipment control was also unknown at this time. Since flexibility was a prime specification, it was felt preferable to build separate flexible controls for the various parts of the computer than to try to combine all the needed flexibility in one central control.

In a new machine we would attempt to combine control functions where possible, hoping to have enough prior knowledge about component needs to eliminate subsidiary controls completely. We still would insist on a large degree of control flexibility.

The master clock consists of an oscillator, pulse shaper, and divider that generate 1- and 2-megacycle clock pulses, and a clock pulse control that distributes these clock pulses to the various controls in the machine. It is this unit that determines which of the subsidiary controls actually is controlling the machine. This unit also stops and starts the machine and provides for push-button operation.

The operation control, see Figure 4, was designed for maximum flexibility and minimum number of operation digits, and, consequently, minimum register length. It is of the completely decoding type.

The operation switch is a 32-position crystal matrix switch that receives the 5-bit instruction from the bus and in turn selects one of 32 output lines corresponding to the 32 built-in operations.

There are 120 gate tubes on the output of the operation control. Pulses on the 120 output lines go to the gate drivers, pulse drivers, and control flip-flops all over the machine; 120 is a generous number. The suppressors of these gate tubes are connected to vertical wires that cross the 32 output lines from the operation switch. Crystals are inserted at the desired junctions to turn on those gate tubes that are to be used for any operation.

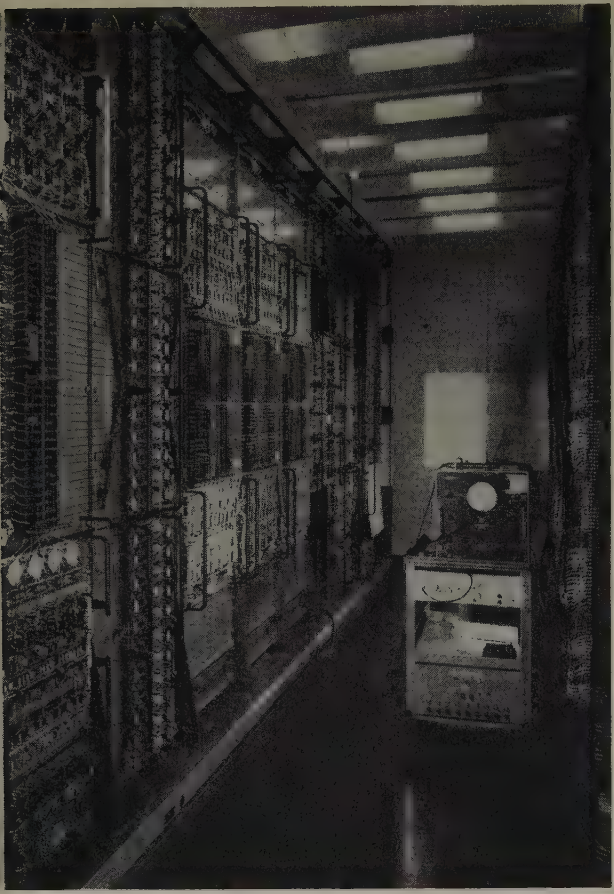

Figure 5. View of central control

The time pulse distributor consists of an 8-position switch driven from a 3-binary-digit counter. Clock pulses at the input are distributed in sequence on the eight output lines. The control grids of the output gate tubes are connected to these timing lines. The output of the operation control is thus 120 control lines on each of which can appear a sequence of pulses for any combination of orders at any combination of times.

The central control of the machine is shown in Figure 5. The control switch is in the foreground with the operation matrix to the right.

ELECTROSTATIC STORAGE

The electrostatic storage shown in Figure 6 consists of two banks of 16 storage tubes each. There is a pair of 32-position decoders set up by address digits read in from the bus. There is a storage control that generates the sequence of pulses needed to operate the gate generators, and so forth. A radio-frequency pulser generates a high-power 10-megacycle pulse for readout.

Each digit column contains, besides the storage tubes, write plus and write minus gate generators and a signal plate gate generator for each tube. Ten-megacycle grid pulses are used for readout in order to get the required discrimination between the fractional-volt readout pulses and the 100-volt signal plate gates. For each storage tube there is a 10-megacycle amplifier, phase-sensitive detector, and gate tube, feeding into the program register. The program register is used for communicating with the storage tubes. Information read out of the tubes appears in the program register. Information to be written into the tubes must be placed in the program register.

ARITHMETIC ELEMENT

The arithmetic element, see Figure 7, consists of three registers, a counter, and a control.

The first register is an accumulator, *AC*, which actually consists of a partial-sum or adding register and a carry register. The accumulator holds the product during multiplication.

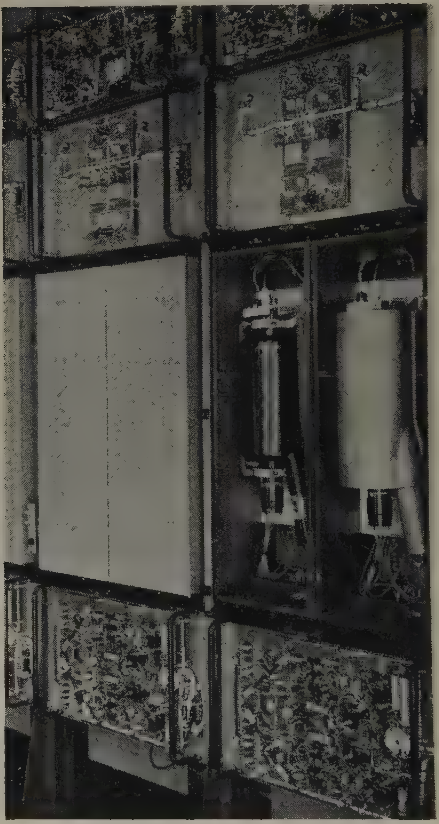

Figure 6. View of electrostatic storage

The second or *A*-register holds the multiplicand during multiplication. All numbers entering the arithmetic element do so through *AR*.

The third or *B*-register holds the multiplier during multiplication. The accumulator and *B*-register shift right or left. A high-speed carry is provided for addition. Subtraction is by 9's complement and end-around-carry. Multiplication is by successive additions, division by successive subtractions, and shift orders provide for shifting right or left by an arbitrary number of steps, with or without roundoff.

The arithmetic element is straightforward except for a few special orders and the high speed at which it operates. Addition takes 3 microseconds complete with carry; multiplication 16 microseconds average including sign correction.

In Figure 8 are shown several digits of the arithmetic element. The large panels are accumulator digits. Above the accumulator is the *B*-register, below it the *A*-register.

TEST CONTROL

TEST CONTROL, shown in Figure 9, is used at present both for operating and for trouble-shooting the computer. The control includes:

1. Power supply control and meters.
2. Neon indicators for all flip-flops in the machine.
3. Switches for setting up special conditions.
4. Manual intervention switches.
5. Oscilloscopes for viewing waveforms. A probe and amplifier system allows viewing any waveform in the computer on one scope at test control.
6. Test equipment to provide synchronizing, stop, or delay pulses at any step of any order of a program, allows viewing waveforms on the fly anywhere in the machine.

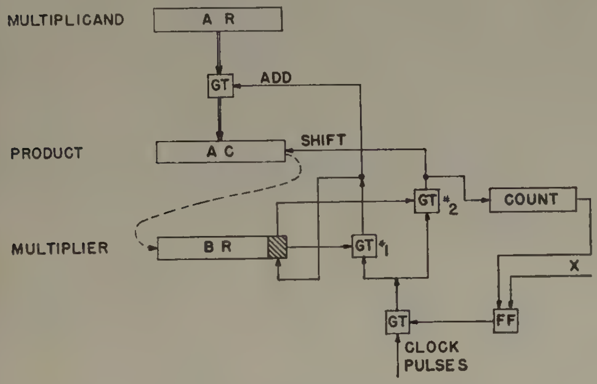

Figure 7. Arithmetic element

An important part of the test facilities is the test storage, a group of 32 toggle-switch registers plus five flip-flop registers that can be inserted in place of any five of the toggle-switch registers. This storage has proved invaluable not only for testing control and arithmetic element before electrostatic storage was available, but also for testing electrostatic storage itself. When not in use for test purposes, test storage participates as part of the terminal equipment system. The toggle-switches hold a standard read-in program; the flip-flop registers are used as in-out registers for special purposes.

CHECKING

LOGICAL CHECKING FACILITIES built into WWI are rather inconsistent. A complete bus transfer checking system has been provided, duplicate checking of some terminal equipment is permitted, but little else is thoroughly checked. It was considered worth while to check some substantial portion of the machine thoroughly. This portion then would serve as a prototype for studying the tube circuitry used throughout the machine. It was not considered worth while to check all the machine, as that requires a great deal of added equipment and logical complexity plus a substantial loss in computing speed.

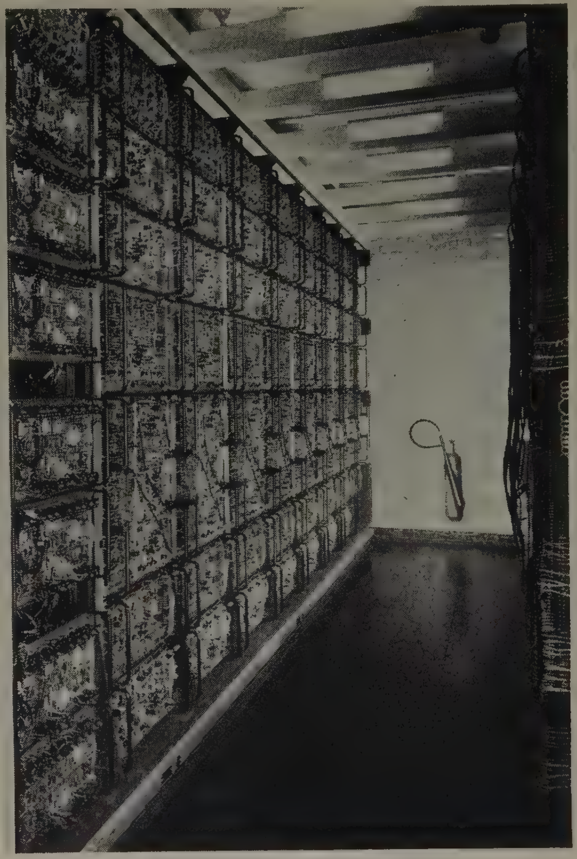

Figure 8. View of arithmetic element

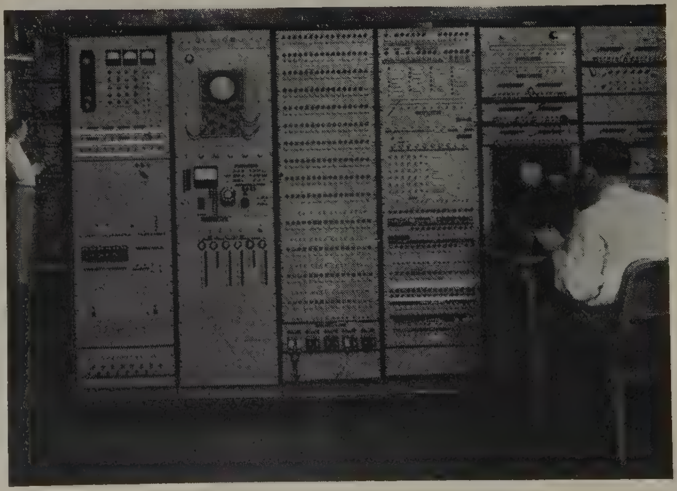

Figure 9. View of test control

Operating experience has shown that it is not worth while to provide detailed logical checking of a machine. In a new machine, the transfer checking would be left out. The amount of information and security provided by the detailed checking system is not considered sufficient to warrant the added expense of building and maintaining it.

This decision is based on the expectation that a computing machine should operate 95 per cent of total time or better and that the average time between random failures should be of the order of 5 to 10 hours, or approximately 10^9 operations.

In our opinion, the way to achieve the extremely high reliability needed in some real-time control problems is to provide three or more identical but distinct machines, thus obtaining error correction as well as detection, plus such features as stand-by, safety, and damage control. Even so the failure probability of each machine must be kept low by proper design, marginal checking, and preventive maintenance.

Extremely high reliability means a reliability far beyond that achieved in existing machines and not conveniently represented as a per cent. Consider a system consisting of three machines, each operable 98 per cent of the time and each averaging 10 hours between random errors.

One machine will be out of operation 1/2 hour per day. Two machines will be out of operation 1/4 hour per month. All three machines will be out of operation 4 minutes per year. Furthermore, undetected random errors might occur on the average of once a year. Such reliability is needed in some systems.

The decision to omit detailed checking does not extend to checking devices intended to detect programming errors. Devices to check for overflow from the arithmetic element or for nonexistent order configurations are necessary. Programmers make many mistakes. Techniques for dealing with programming errors are very important and they are in need of considerable further development.

TERMINAL EQUIPMENT

At the present time, WWI is using the following terminal equipments:

1. A photoelectric paper tape reader.
2. Mechanical paper tape readers and punches.
3. Mechanical typewriters.
4. Oscilloscope displays 5 to 16 inches in diameter with phosphors of various persistences including a computer-controlled scope camera.
5. Inputs from various analogue equipments needed for control studies.
6. Outputs to analogue equipments.

To be added during the next year:

1. Magnetic tape (units by Raytheon). One such unit is now being integrated with machine.
2. Magnetic drums (units by Engineering Research Associates, Inc.).
3. Many more analogue inputs and outputs.

This great complexity of terminal equipment requires a flexible switching system. There is a single in-out register (IOR) through which most of the data pass.

There is a switch which is set up by an order to select the desired piece of terminal equipment. Other orders put data into IOR or remove data from IOR. The in-out control provides the necessary control pulses to go with each type of equipment. In general, the computer continues to run during terminal equipment wait times; suitable interlocks are provided to prevent trouble. This complete equipment has not been fully installed yet.

New Pulse Klystron Amplifier for the 960-1,215-Megacycle Region

CAROL VERONDA
ASSOCIATE MEMBER AIEE

IN CONSIDERING the main objectives of pulsed amplifier development, it is, of course, most important to obtain the required peak power output. In the case of this klystron, various requirements ranged from 5 kw to $17^1/_2$ kw peak radio-frequency (r-f) power output. Average power output requirements ranged from 50 to 300 watts with a special requirement of variable duty cycle in one case. A klystron amplifier is easily capable of these output powers at the frequencies involved.

A second important consideration is the power gain. A high gain is very helpful since it eliminates the need for extra stages of amplification. Frequency stability is assured since the tube is an amplifier and the frequency is determined by previous low level stages.

In the third place, it is usually desirable to work at as low a beam voltage as possible, consistent with gain, efficiency, and other characteristics which must be compromised to obtain a lower beam voltage.

There are many other desirable features to be obtained by a given design, but the most important ones are thermal compensation against ambient temperature changes, a wide tuning range, and simplicity.

Carol Veronda is with the Sperry Gyroscope Company, Great Neck, N. Y.

This klystron is a cascade amplifier developed expressly for crystal-controlled pulse operation in the 960- to 1,215-megacycle range for air navigational aids. It is designed for use either with a variable-duty or fixed-duty cycle. Some of the design concepts, tube design, and its characteristics are discussed.

DESIGN CONCEPTS

In the usual klystron the beam is maintained in its cylindrical shape over the required interaction distance by ion focusing or by magnetic focusing. This is not true with the *SAL-39* klystron. In the case of this design, it would have been disadvantageous to use magnetic focusing because of the complexity which would be added.

Ion focusing is accomplished by neutralization of the electronic space charge of the beam by positive ions formed from the residual gas molecules which are present in sufficient numbers even at the very low pressures ($<10^{-7}$ millimeter of mercury) inside a klystron. However, where microsecond pulse operation is required, ion focusing is useless since no ions are present for the first few microseconds to neutralize the beam space charge, when the beam is first turned on and, therefore, the beam spreads rapidly. Ion build-up requires from several microseconds to several hundred microseconds depending on the pressure, the geometry involved, and other factors. Furthermore, very few ions are left from preceding pulses even at very high repetition rates since ion recombination at the metallic drift tube walls is very rapid at the low pressures involved.

In the case of the *SAL-39* klystron it was necessary, therefore, to utilize space-charge focusing. That is, the beam is allowed to follow a trajectory determined by the initial angle of the electron gun and by the mutual space-charge repulsion forces of the electrons. The beam comes down to a minimum and then spreads out so that it does not have a uniform diameter over its length. The tube was designed to fit around this spreading beam and, therefore, had to be kept comparatively short. The general design of the tube is now established. A schematic cross-section view of the tube is shown in Figure 1.

The tube designer is faced with the problem of deciding whether to use a 2-resonator structure with a long drift length or go to a 3-resonator cascade amplifier design with two, comparatively short, drift lengths. The cascade design offered a higher gain than would be possible with a 2-resonator tube. Furthermore, cascade bunching will give a higher efficiency than will a 2-resonator klystron since the rebunching of the beam at the second or floating resonator of a cascade amplifier increases the effective r-f current at the output gap. Since the increased gain and improved efficiency of the cascade design more than offsets the slight complication of a third resonator, this design was chosen.

In determining the operating beam voltage to be used, the perveance of the electron gun, that is the relationship between current and voltage, must be selected. The perveance is defined as the beam current divided by the beam voltage to the 3/2 power. The perveance of a space-charge-limited cathode is a function only of the geometry of the electron gun and anode. The space charge spreading of the beam is a function of the perveance. The optimum drift length to obtain maximum gain decreases as the perveance increases since the space charge debunching forces in the beam depend on perveance also. In selecting the perveance to use for this tube, it can be seen qualitatively that the beam voltage necessary for a given power input decreases as the perveance is increased, the distance the beam will travel for a given amount of radial spread will decrease, and the optimum gain drift length will decrease. An analysis shows that the percentage of optimum drift length available with a given radial spread varies slowly with perveance (as about $K^{0.3}$) so that other factors must be considered in determining the perveance.

These other factors are the relative proportions of resonator loading and beam loading, and the effect on electronic conversion efficiency of high bunching voltages. If the perveance is too low, the resonator loading will take an undue amount of power; that is, the circuit efficiency and bandwidth will be low since the beam resistance is high compared to the resonator resistance. If the perveance is too high, the high bunching voltage, required because of increased space-charge debunching, will lower the conversion efficiency since the drift length is shorter than optimum. A compromise must be made, and after careful consideration of the factors involved, the perveance of the design was made 3×10^{-6} ampere-(volts)$^{-3/2}$.

With a space-charge focused beam it was desirable to make the initial beam diameter as large as possible in order to get as long a beam as possible. The input and output gaps, therefore, have as large an electrical diameter as possible while still maintaining a reasonably constant r-f voltage across the diameter. The input and output resonators were made singly re-entrant in order to take the fullest possible advantage of the beam length available. Grids were, of course, required to assure a more uniform

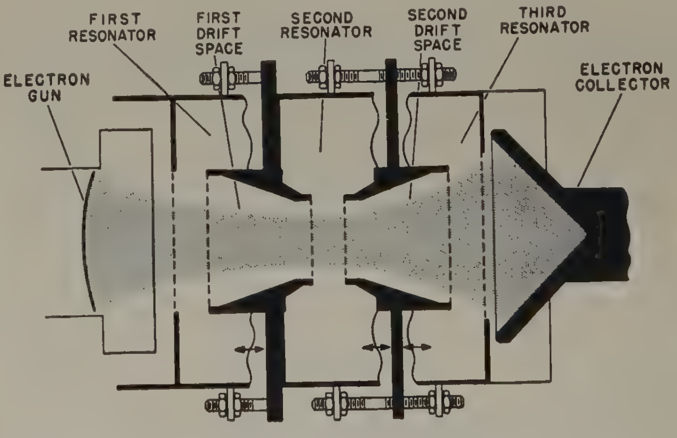

Figure 1. A schematic cross section of the space-charge focused klystron in which the nonuniform cross section of the beam is indicated by the shaded area

field at the large diameter gaps. The middle gap diameter was made smaller since the beam diameter is smaller at this point. The middle resonator is floating; that is, it is not loaded by an input or output line so that its natural bandwidth tends to be lower than the other resonators. The smaller gap diameter coupled with a doubly reentrant post structure makes the capacity at the middle resonator gap less than the other resonators. Since the beam loading is much heavier than the resonator loading, this makes the middle resonator bandwidth about equal to the other resonators.

In any tube it is desirable to have as large a tuning range as possible consistent with other requirements. The selection of gap tuning by means of tuning screws was very natural for this application in order to cover the entire 960–1,215-megacycle band. In tuning from 960 to 1,215 megacycles, the interaction-gap transit angle goes from about 1/2 radian to $1^1/_2$ radians. The power output hardly varies since the grids have been made very transparent to the electrons, thus minimizing secondary-electron loading effects which vary rapidly with transit angle. It is interesting to note that about 80 per cent of the cathode current reaches the collector after passing through six grids.

Temperature compensation of the resonator against ambient temperature changes is an important consideration in any klystron design. A separate, but closely related problem is compensation against input power changes which occur during variable-duty-cycle operation in the case of this pulse klystron. These problems are made simpler if short heavy heat paths are maintained throughout the tube structure. The dissipation ability of the tube is improved thereby, and the thermal time constants are kept as short as possible. In this tube, thermal compensation against ambient temperature was achieved by means of bimetallic effects in the resonator structure. No special means for input power compensation was necessary after ambient compensation since the thermal gradients caused by input power were kept to a minimum by the heavy short thermal paths of copper and by the good beam transmission obtained.

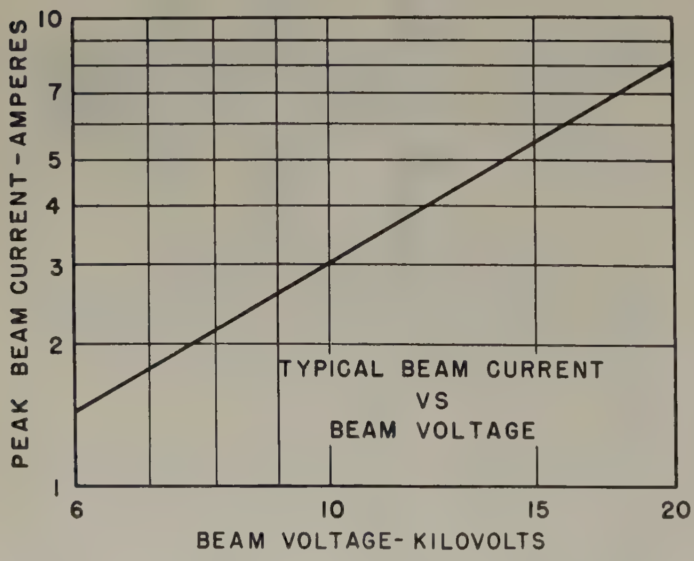

Figure 2. The peak beam current plotted against the beam voltage gives a straight line on 2/3-power paper

TUBE STRUCTURE

An electrostatic electron gun with an aperture-cylinder type of focus electrode is used in the *SAL-39* klystron. The focus electrode is operated at cathode potential, and is attached internally to the cathode. The electron gun semiangle is 10 degrees in order to obtain as long a beam as possible with the space-charge focused beam used in the tube. As previously mentioned, the perveance of the gun is 3×10^{-6} ampere-(volts)$^{-3/2}$. A plot on 2/3-power paper of the peak beam current in amperes versus the peak beam voltage in kilovolts is shown in Figure 2.

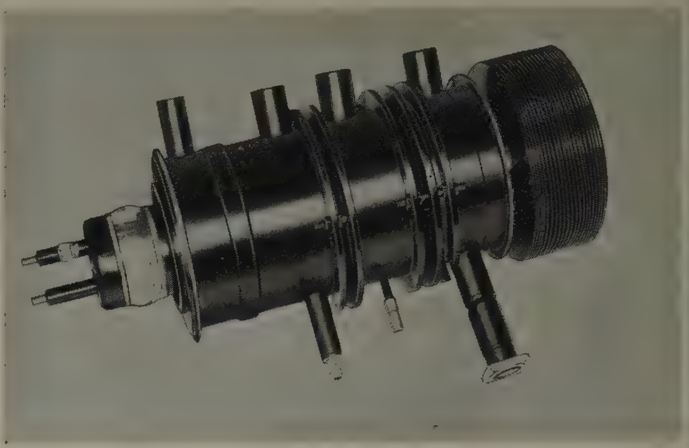

Figure 3. The SAL-39 klystron is about 18 inches long and 6 inches in diameter

The cathode itself is a spherical segment about 2 inches in diameter and is oxide coated. It is run at a conservative current density for pulse emission at the duty cycles involved—about 0.3 ampere per square centimeter peak at the usual voltages. The heater is run at 5 volts ±10 per cent, 43 amperes, alternating or direct current. In any klystron amplifier, the cathode is completely removed from the r-f interaction region. The cathode is simply a diode that has no way of knowing whether or not the r-f power is on; this means that there are no electron back-bombardment effects present.

The electron collector is also separated from the interaction portion of a klystron amplifier and, therefore, can be made for dissipating the required power conveniently. The collector is air cooled: the collector and tube require about 200 cubic feet per minute of air at the maximum input rating of 2,400 watts.

Figure 3 shows the *SAL-39* klystron; the heater and heater-cathode terminals are at the left with the glass beam-voltage insulator. The input connector is a type-BNC jack as is the monitor connector which is used for tuning purposes. The output connector is a standard 7/8 coaxial line terminal. The tuning screws for the input, middle, and output resonators can be seen. The tube weighs about 24 pounds and is about 18 inches long and 6 inches in diameter.

TUBE CHARACTERISTICS

A TABULATION of some typical operating parameters of the klystron is shown in Table I. Peak output powers of from 4 to 30 kw are obtained at various beam voltages as will be seen later. The plate efficiency normally is about 25 per cent and the gain varies from about 2,500 down to about 300, depending on the amount of middle resonator detuning, as also will be seen later. The tube is capable of handling average input powers up to 2,400 watts at duty cycles up to 12 per cent and pulse lengths up to 10 microseconds.

Table I. Typical Operating Conditions of SAL-39 Cascade Amplifier Klystron

Frequency 960 to 1,215 Megacycles

Output power	4	30 kw
Beam voltage	8	18 kv
Beam current	2.2	7.2 amperes
Radio-frequency drive power (nominal)	30	220 watts
Radio-frequency drive power (max. gain)	2	10 watts
Efficiency	20–30 per cent	
Average input power (max.)	2,400 watts	
Pulse length	0.5–10 microseconds	
Bandwidth (gain ≈ 300)	1 per cent	
Heater voltage	5.0 ±10 per cent volts a-c or d-c	
Heater current	43 amperes	

Figure 4 is a log-log plot of peak power output in kilowatts versus the peak beam voltage in kilovolts. It will be noticed that the power output can be varied over wide ranges by varying the beam voltage. The efficiency remains fairly constant over this wide range of power outputs.

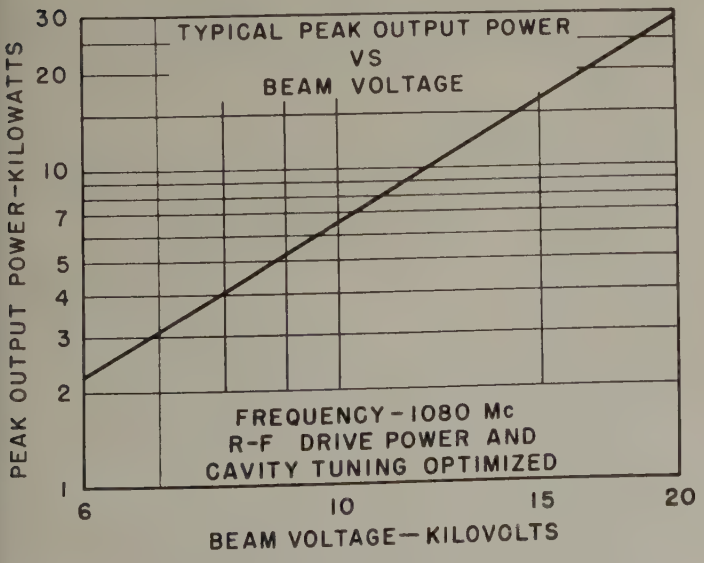

Figure 4. Peak power output plotted against peak beam voltage

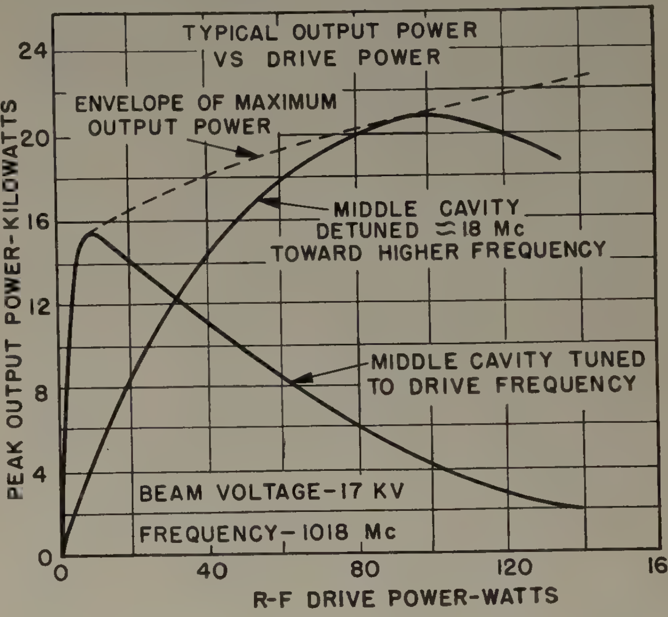

Figure 5. Peak power output plotted against peak radio-frequency drive

Figure 5 is a plot of peak-power output in kilowatts versus the peak r-f drive in watts. This particular curve is for a peak beam voltage of 17 kv. The solid curve which peaks at a drive power of 7 watts is for operation of the tube with all three resonators tuned to the drive frequency. The other solid curve is for operation with the middle resonator detuned toward higher frequency by about 18 megacycles (3 half bandwidths). It will be noticed that the output power, and thus the efficiency, increases rapidly. This is a direct result of the increase of effective r-f current resulting from the phasing of the middle resonator cascade bunching. Thus, gain may be traded for increased efficiency. It is interesting to note that the efficiency picks up more rapidly with middle resonator detuning than does the usual 3-resonator klystron. This occurs since the r-f bunching voltage in the middle resonator is quite high when the tube is synchronously tuned (about $V_{r-f}/V_{beam}=0.5$), and the drift length could be made only about 1/2 optimum, thus leading to a rather large spread in electron speeds at the output gap. As the drive power is increased and the middle resonator detuned toward higher frequencies, not only does the usual improvement result from the improved phasing of the cascade bunching but also the bunching carried over from the first gap increases. The first gap is about the optimum drift length from the output gap. The middle gap bunching voltage is reduced and there is considerably less spread in the electron speeds at the output gap, thus the conversion efficiency tends to be higher.

CONCLUSION

THE BASIC DESIGN, some design details, and the typical operating characteristics of the *SAL-39* cascade amplifier klystron have been reviewed briefly. To summarize the characteristics of the tube: it is capable of peak power outputs of from 4 to 30 kw at an efficiency of about 25 per cent over the frequency range of 960 to 1,215 megacycles and it has a very high r-f power gain ranging from about 300 to 2,500 when synchronously tuned. The tube was expressly designed for pulse application and can be used in a wide variety of applications for pulse service.

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The Impulse Generator and Its Uses

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DURING THE PAST 30 years improved design and insulation techniques have approximately doubled the impulse strength of high-voltage power transformers. The impulse generator has played an important role in this development. The purpose of this article is to discuss the principal uses of the impulse generator as related to the manufacture of transformers. These uses may be divided into two categories: fundamental study and verification and quality control.

A new field of investigation was opened up by the use of the impulse generator to obtain fundamental data. The dielectric properties of air subjected to impulse voltages were investigated, then studies were extended to include various kinds of insulating materials used in transformers. Life-size barrier models built up from combinations of materials were tested to destruction to determine their characteristics on impulse voltages. In these tests frequent inspections were made as a check on the detection of the beginning of deterioration. With the impulse characteristics of various insulating materials and barrier structures known, the next logical step in the improvement of the transformer was to use the impulse generator to test life-size models of complete transformers. These tests were carried to destruction to determine ultimate strength data. This information was used to formulate proper design data for all commercial ratings proposed for use in this country.

The impulse generator has been developed into a valuable tool for demonstrating the dielectric strength of transformers. The first commercial impulse test on a power transformer was made more than 20 years ago. It soon was realized that these standardized tests were too complicated and time-consuming for general use in controlling quality in the production line. The transformer division of the Westinghouse Electric Corporation devised effective quality-control impulse tests suitable for such uses.

The first quality-control test was a very simple one. It was applied to distribution transformers starting June 1, 1934. Two waves, with a magnitude sufficient to flashover the De-ion gaps, were applied to each end of the high-voltage winding with the other end grounded. This simple impulse test has proved to be valuable in keeping the quality of these transformers at a high level.

The next quality-control test developed was for completely self-protected distribution transformers. A dual purpose was to be accomplished. In addition to subjecting the transformer to impulse voltages, it was desired to test the De-ion gaps with high-impulse currents. A combined impulse-voltage and surge-current generator was used to simulate a direct stroke. The transformer, excited as in service, is subjected to a voltage rising at 300 kv per microsecond to the limit of the De-ion gap and a surge current of 55,000 amperes follows. Up to January 1, 1950, a total of 421,000 units, or 2,500,000 kva, had been direct-stroke tested. This test has led to many improvements in the transformers and protective equipment.

The success of the quality-control tests described and satisfactory experiences in commercial impulse testing led to the development of a quality-control impulse test for power transformers, beginning June 1, 1944. The fundamental objective was to simplify the test sufficiently to make it possible to test essentially all units and yet to keep the severity of the test comparable to the standard test. To accomplish this objective, each line terminal, with the transformer unexcited, is subjected to two chopped waves followed by two full waves within ±5 per cent of American Standards Association (ASA) levels.

At the present time, quality-control testing is applied on a sampling basis to a major portion of the highly repetitive lines. For the larger and more specialized units, the objectives are to test as many as is practical without limiting production. To accomplish this, a total of six impulse-voltage and current generators, ranging up to 3,600,000 volts, are assigned to quality-control and commercial testing.

Detection of failures is a major problem in impulse testing. Voltage oscillograms have proved to be the most dependable and informative of any one method of fault detection. They apply alike to front-of-waves, chopped waves, and full waves. Full use also is made of the physical evidences of trouble, such as noise, smoke, bubbles, and failure of the chopping gap to flashover. Excitation and ground-current measurement are useful in investigating trouble. As a final precaution in detection, the low-frequency tests are always made after the impulse tests.

Failures during impulse testing have served as a valuable source of information and have led to many important improvements in design. Each case of trouble is analyzed carefully to determine the cause and the means to avoid future similar difficulties. In this way, design methods are being improved continually. This fact is shown by the trend in the rate of failures. The failure rate from 1931 to 1944 was 15 per cent. By 1947, out of 500 units impulse tested, 10 per cent failed. In 1949, with more than double the units tested, only 3 per cent failed. Since that time the quarterly failure rate has been between 3 and 6 per cent.

To test transformers in large quantities, the test procedures should be kept as simple as is consistent with effective testing. Our test records show that a satisfactory quality-control test for power transformers is two chopped waves followed by two full waves with a permissible tolerance of ±5 per cent of ASA impulse test levels.

Digest of paper **52-77**, "The Impulse Generator and Its Uses," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Investment Costs for Use in the Economic Comparison of Alternative Facilities

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The divergent practices followed in preparing investment cost estimates are discussed, and a plea for consistency made. Many specific problems such as "out-of-pocket" costs, indirect construction costs, and retirement of facilities also receive attention.

THE SUBCOMMITTEE on System Economics has undertaken to develop material on the general subject of "economic comparisons of alternative facilities or installations." Initially, it is planned to consider the methods of treating the various basic factors that enter into the application of evaluation methods to the many general and specific types of engineering problems in the field, to be followed later by papers showing the application of the various basic factors to a sufficient variety of different general and specific types of problems, actual or hypothetical, to provide adequate coverage of the subject.

The basic factors in studies of the relative economics of alternative facilities may be considered under the following classifications:

1. Investment costs.
2. Fixed charges.
3. Operating and maintenance costs.
4. Energy value.
5. Capacity value.
6. Effect of the future values of the foregoing factors on the present relative merits of the alternate facilities.

This article deals with the factor of investment costs. Four previous papers treated other related problems.[1–4]

ELEMENTS OF INVESTMENT COSTS

THE ELEMENTS of investment costs are considered along the following lines:

1. The extent to which investment costs used for purposes of economic evaluations should parallel the bookkeeping practices relating to the accounting for such items.
2. So-called "out-of-pocket" costs or "new money" required.
3. Interest during construction.
4. Stores charges.
5. Allocation of various indirect construction costs.
6. Retirements of existing plant and equipment made in connection with the installation.
7. Retirement of the cost of plant and equipment constituting the complete facility.

The article includes an answer to the question: "To what extent should the services of current personnel and facilities, included in the investment costs used for economic evaluations, be the incremental cost as compared with, say, the average cost of such items as entered in the construction cost records."

However, this article should not be construed as a final answer to the various problems which are discussed but rather as a starting point for fruitful discussion.

ESTIMATED COSTS USED IN COMPARISON OF ALTERNATIVE FACILITIES

IN SETTING UP investment costs for use in the economic comparison of alternative facilities, it is obvious that these must be based on careful estimates. The alternative facilities, for instance, may involve additional generating capacity in the form of hydroelectric power, thermal power from steam, diesel or gas-turbine plants, or an interconnection with a nearby plant or power system. Estimates cannot be based on historical costs, with any degree of accuracy, because the circumstances surrounding the prospective new facilities are never the same as those associated with existing plants.

It is only too true that any engineer can build facilities which may serve the apparent purpose, if he is permitted to disregard all economics of design and construction, and has enough material and labor, as has happened during military emergencies. However, the prudent owner must base his judgment on the soundest possible estimates.

If the estimate is unsound, the decision to proceed with the construction of a particular facility, after an economic comparison of alternatives has been made, may involve the owner in serious losses. Therefore, too much emphasis cannot be placed on sound and coherent estimates. These take account of all costs which would enter into the construction of such a facility.

The first step in the comparison of facilities is the conversion of specific engineering features into definite prospective expenditures. Only by placing alternatives on an equivalent basis can they be evaluated, taking into account the time-cost of money.

Most engineers engaged in estimating work are familiar with and apply such well-known economic criteria as Kelvin's Law in transmission-line work, and Adam's Theorem. The latter states that a particular design is

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most economical when the sum of the total annual operating charges, the desired net return on the investment, and the value of energy lost therein is a minimum. Both are applicable with no limitation in available investment funds. Another important economic criterion originates from the Law of Diminishing Returns. It may be expressed as: the amount of a product obtained in a productive process varies with the way the factors of production are combined. If only one factor is varied, the production per unit of this factor may increase to a maximum amount, after which it may be expected to diminish but not necessarily proportionately.

Engineering literature contains many instances of principles underlying the economic design of components of a complete structure or development. However, relatively few engineers carry such thinking through consistently. Many are imbued with extremely individualistic ideas which, in the over-all picture, exercise undue influence. All too few, for instance, bear in mind and practice rational standardization.

Since engineering features only can be appraised economically in terms of expenditures and receipts, it is necessary that cost estimates be based on reasonably comprehensive preliminary plans and engineering studies. In many cases, it may be highly advisable to resort to model studies, as in the case of hydroelectric developments. Where transmission facilities are involved, network-analyzer investigations may be warranted. Use of a network analyzer on long transmission or heavily loaded short transmission networks, taking into account rotating-machine, transformer, and load characteristics, can be a very powerful tool in economic comparisons of alternative facilities.

This leads to the consideration that the cost estimates prepared by individual engineers or engineering groups working on components of a project should be reviewed by an engineer of wide over-all experience.

Table I. Summary of Power Plant Accounts

Hydroelectric		Thermal		Internal Combustion	
Account No.	Item	Account No.	Item	Account No.	Item
			Intangible Plant		
301	Organization	301	Organization	301	Organization
302	Franchises and consents	302	Franchises and consents	302	Franchises and consents
303	Miscellaneous intangible plant	303	Miscellaneous intangible plant	303	Miscellaneous intangible plant
			Production Plant		
	Preliminary Engineering and Surveys		*Preliminary Engineering and Surveys*		*Preliminary Engineering and Surveys*
320	Land and land rights	310	Land and land rights	330	Land and land rights
	Direct Construction Cost		*Direct Construction Cost*		*Direct Construction Cost*
321	Structures and improvements	311	Structures and improvements	331	Structures and improvements
322	Reservoirs, dams, and waterways	312	Boiler plant equipment	332	Fuel holders, producers, accessories
323	Water wheels, turbines, generators	313	Engines, engine-driven generators	333	Internal combustion engines
324	Accessory electric equipment	314	Turbogenerator units	334	Generators
325	Miscellaneous power plant equipment	315	Accessory electric equipment	335	Accessory electric equipment
326	Roads, railways, bridges	316	Miscellaneous power plant equipment	336	Miscellaneous power plant equipment
	Construction power				
	Subtotal		Subtotal		Subtotal
	Indirect Construction Cost		*Indirect Construction Cost*		*Indirect Construction Cost*
	Engineering, design, consulting engineering fees		Engineering, design, consulting engineering fees		Engineering, design, consulting engineering fees
	Construction supervision, procurement		Construction supervision, procurement		Construction supervision, procurement
	Construction fee		Construction fee		Construction fee
	Subtotal		Subtotal		Subtotal
	Interest during construction		Interest during construction		Interest during construction
	Contingencies		Contingences		Contingencies
	Total		Total		Total
			Transmission Plant		
	Preliminary Engineering and Surveys		*Preliminary Engineering and Surveys*		*Preliminary Engineering and Surveys*
340	Land and land rights	340	Land and land rights	340	Land and land rights
	Direct Construction Cost		*Direct Construction Cost*		*Direct Construction Cost*
341	Clearing land, rights of way	341	Clearing land, rights of way	341	Clearing land, rights of way
342	Structures and improvements	342	Structures and improvements	342	Structures and improvements
343	Station equipment	343	Station equipment	343	Station equipment
344	Towers and fixtures	344	Towers and fixtures	344	Towers and fixtures
345	Poles and fixtures	345	Poles and fixtures	345	Poles and fixtures
346	Overhead conductors, devices	346	Overhead conductors, devices	346	Overhead conductors, devices
347	Underground conduit	347	Underground conduit	347	Underground conduit
348	Underground conductors, devices	348	Underground conductors, devices	348	Underground conductors, devices
349	Roads and trails	349	Roads and trails	349	Roads and trails
	Subtotal		Subtotal		Subtotal
	Indirect Construction Cost		*Indirect Construction Cost*		*Indirect Construction Cost*
	Engineering, design, consulting engineering fees		Engineering, design, consulting engineering fees		Engineering, design, consulting engineering fees
	Construction supervision, procurement		Construction supervision, procurement		Construction supervision, procurement
	Construction fee		Construction fee		Construction fee
	Subtotal		Subtotal		Subtotal
	Interest during construction		Interest during construction		Interest during construction
	Contingencies		Contingencies		Contingencies
	Total		Total		Total

ESTIMATED INVESTMENT COSTS AND ACCOUNTING PRACTICES

The estimates of investment costs for use in the comparison of facilities normally serve an immediate purpose in reaching a decision as to which alternative is actually constructed. Such being the case, these same estimates should be so prepared that they form the basis for the authorization of expenditure on the proposed work, and can be compared with the actual construction costs, and finally, the asset records. Accordingly, the setup of the estimate should correspond to the cost subdivisions as they will eventually appear in the asset records.

In the power-system field, where requirements of the regulatory authorities must be considered, the uniform system of accounts for electrical utilities[5] is widely used for accounting purposes. It is utilized, to a substantial extent, by engineers and consultants preparing estimates of investment costs for use in the comparison of facilities, but far less than appears de-

Table II. Comparison of Estimates Prepared for Economic Studies of Power Facilities by Five Consulting Engineering Groups

I	II	III	IV	V
Direct Costs				
Labor and material	Labor and material	Labor and material	Labor and material	Labor and material
Construction equipment charges	Charges for use of construction equipment	Construction equipment charges	Construction equipment charges	Construction equipment charges
Transportation charges	Transportation charges for men, material, and permanent equipment	Transportation charges	Transportation charges	Transportation charges
Permanent equipment charges	Permanent equipment charges	Permanent equipment charges	Permanent equipment charges	Permanent equipment charges
	Contingency allowances for major components			
Subtotal—Direct Costs				
Indirect Costs				
Preliminary surveys and engineering	Allowance regarding loss of earnings on contractor's equipment during transit to site	General supervision and procurement	Engineering and drafting	Contingencies
Engineering design and construction	Charges for transportation of contractor's equipment to and from site, inclusive of repair parts	Engineering	Field supervision	Engineering
Contingencies	Engineering	Fee	Out-of-pocket expense	Interest during construction
Construction power	Supervision and miscellaneous general expenses	General contingencies	Miscellaneous construction expense	
Interest during construction		Equipment contingencies		
		Interest during construction		
Grand Total Cost				

sirable. It is not the author's intention to express an opinion on the soundness of this work. Rather it is intended to stress that it provides a workable skeleton which can be used for setting up estimates of investment costs and utilized in the economic evaluation of facilities. Then they can readily form a basis for approval of construction expenditures, be compared with actual construction costs and eventually with the asset records, as each will have comparable subdivisions of costs.

Regardless of whether the facility built as a result of this comparison of alternatives entails a hydroelectric, thermal, or internal-combustion power plant, or transmission plant, this work provides a strictly comparable system of accounts, which can be subdivided to the extent found desirable.

If the direct construction cost accounts embody direct labor and material charges, all charges for use of construction plant, transportation charges, and permanent equipment costs, there is very little difficulty in the preparation of comparable estimates of investment costs, in so far as direct construction cost charges are concerned. This leaves us with the indirect construction costs, which broadly embrace:

1. Engineering, design, and consulting engineering fees.
2. Construction supervision and procurement costs.
3. Construction fee.
4. Owner's administration costs.
5. Interest during construction.
6. Contingencies.

If the estimates of investment cost are sound, the item of contingencies will not cover errors of omission in the estimates but rather those unforeseen developments during construction, such as more difficult foundation conditions, strikes, and so forth, which may add to the ultimate cost. There seems to be no sound basis for charging interest during construction on the allowance for contingencies.

In line with the foregoing, Table I is a comparison of the major accounts which can be used for hydroelectric, thermal, and internal-combustion plants, and transmission facilities, essentially in line with reference 5.

PREPARATION OF ESTIMATES

Widely different procedures are followed by owners, whether individual or corporate, in the preparation of estimates of investment costs for use in the comparison of facilities. In some cases, the owner's engineering department undertakes the entire work and responsibility. In others, a firm of consulting engineers is engaged, and carries out the entire study, presenting conclusions or recommendations and supporting analyses to the owner for decision. In still others, the owner retains consultants whose estimates and recommendations are reviewed by the owner's engineering department.

No matter what procedure is followed, there is an extremely wide divergence in the methods by which estimates are prepared. Two different firms of consultants working on the same basic facts, who arrive at the same estimate of direct costs, will come up with entirely different final or over-all costs. This can be most misleading. Table II is a comparative illustration of the manner in which five different consulting engineering groups actually may prepare estimates for the economic appraisal of power-supply facilities.

The manner in which indirect construction costs are estimated varies amazingly. Some estimators compute interest during construction on all costs including contingencies; others apply it on all costs except contingencies.

In the light of this situation, which is not exaggerated, is it any wonder that the busy executive faced with the necessity of making decisions involving the expenditure of substantial sums of money, or the owner himself, sometimes throws up his hands and wonders what is the matter with engineers in general?

"OUT-OF-POCKET" COSTS

Investment may be defined as the process of putting money into certain facilities with the expectation of getting an income and/or profit in the future from the operation of said facilities. Since money required to be invested in the facilities is the common denominator by which several alternatives can be evaluated, all costs must be included. If only the "out-of-pocket" costs or "new money" required is taken into account, the economic comparison of alternative facilities is likely to be seriously distorted. Frequently the amount of the "out-of-pocket" cost or "new money" required varies widely with the different alternatives under study. In some instances, however, where the facility involved may entail only a moderate total investment, circumstances may be such that the "out-of-pocket" costs may be the measure of benefit to be received and hence the governing influence in reaching a decision.

INTEREST DURING CONSTRUCTION

INTEREST DURING CONSTRUCTION must be taken into account in economic comparisons of alternative facilities as an actual construction cost. It is a recognition that capital is unproductive during the period of construction. Whether or not interest during construction of a particular facility is charged to capital varies with different owners, depending on the source of investment funds and policy. For instance, surplus funds may be utilized. In such cases, taxation considerations have to be taken into account.

In unregulated industries, the amount of interest during construction of new facilities is ordinarily limited to the actual interest paid on borrowed funds, but this is an accounting convention which is inconsistent with the true meaning of interest during construction, which reflects the economic cost of temporarily unprodicitve funds. On the other hand, in regulated industries such as public utilities, regulatory bodies recognize the true meaning of interest during construction by providing that a reasonable rate of interest on the owner's own funds shall be charged as part of the cost of construction. In this case, interest during construction is construed to be the current cost to the owner per dollar of total capital and not the current cost of borrowed capital or common-stock capital. However, some regulatory bodies provide that funds specifically acquired to finance construction, and separately held for such purpose, shall be reflected in the accounts to the extent of the net interest payments; such provision is not a true measure of the economic cost of the specifically borrowed capital, since a part is actually carried by the owner, whether an individual or a group of stockholders.

The appropriate rate of interest during construction to be assumed in economic comparisons of alternative facilities is the current cost per dollar of total capital to the owner. It is not the cost of the owner's capital which has been experienced in the past, but that of additional capital made up in a balanced manner corresponding to the existing capital setup of the owner.

Engineers engaged in the preparation of estimates of investment costs for use in the economic comparison of alternative facilities follow widely varying practices in computing interest during construction. In some cases, the interest is computed by taking the estimated total investment cost and multiplying it by the simple interest rate per annum divided by two and multiplying by the number of years in the construction period. In other cases, interest is computed on the anticipated yearly disbursements.

Since interest during construction recognizes the fact that capital committed to the new facility is unproductive during the construction period, such interest becomes an item of temporarily unproductive capital; obviously interest has to be allowed on the interest incurred during the preceding portions of the period of construction. Recognition of this leads to the conclusion that the proper procedure is to use compound interest during the construction period.

STORES CHARGES

ALL ITEMS OF cost entering into the construction of alternative facilities obviously should be taken into account if a true economic comparison is to be made. This means that the estimator should make an appropriate allowance for materials and supplies normally withdrawn from the stores department, an item perhaps all too frequently overlooked in a large organization. An allowance likewise should be made for the necessary burden resulting from the cost of operating stores facilities.

APPLICATION OF INDIRECT CONSTRUCTION COSTS

INDIRECT CONSTRUCTION or overhead costs are those costs incurred as part of the total cost of construction of a given facility not traceable or identified readily with a particular component or unit of the facility, and ordinarily distributed to the appropriate component accounts by some suitable basis of allocation for accounting convenience.

The term "indirect construction" is undoubtedly preferable to "overhead," since ordinarily "overhead" costs mean those costs of doing business which cannot be attributed directly to a specific phase of the business.

If a correct decision is to be reached, all indirect construction costs must be taken into account in the preparation of estimates of investment costs for use in the comparison of facilities. In the execution of that decision and construction of the facility decided on, such costs must be fully charged and appropriately allocated so that, eventually, the entire costs of the facility, both direct and indirect, can be deducted when the facility, or major component thereof, is retired. This is implicit in sound utility management, where the requirements of regulatory authority apply. It is also implicit in the sound management of any other business, although practice varies somewhat.

Indirect construction costs include such items as:

1. Engineering.
2. Supervision.
3. Indirect labor charges and related expenses.
4. Insurance.
5. Taxes during construction.
6. Administrative and general expense.
7. Interest during construction.

Allocation of indirect construction costs is not directly a problem in the preparation of estimates of investment costs for use in the economic comparison of facilities, except to the extent that such costs must be distributed over the costs of the major components or categories of the complete facility in order that depreciation charges can be properly computed.

However, having regard to reference 5, it would appear that distribution of indirect construction costs should be made in keeping with the same procedure as followed in the accounting practice of the particular owner. Thus, it may be quite logical in some instances to use a composite depreciation rate for the entire facility, rather than different rates for the several components. Even in these instances, the preparation of a composite depreciation rate will entail distribution of indirect construction costs to the accounts for major components.

An expanding public-utility undertaking normally undertakes additions and improvements to facilities on an almost continuous basis. If the construction of these additions and improvements is carried out by contractors, the contractors' invoices will show, in major part, all indirect construction costs incurred. However, where the public utility undertakes its own construction activities and actually incurs indirect construction costs very similar to those which would be incurred by independent contractors, the question originates as to the appropriate indirect construction costs to be charged. The problem arises in properly allocating the costs of specialized services normally available in the utility organization which are utilized on operation and maintenance as well as on the design and in the execution of the additions and improvements contemplated.

Construction of its own additions and improvements is frequently more economical for the public utility than if outside contractors are retained. The experienced organization which is normally available, and the use of such organization on construction will result undoubtedly in lower operation and maintenance costs during the period of construction activity, due to personnel working at a higher tempo.

Reference 5 stipulates that the indirect construction costs added to specific accounts must be reasonably applicable; they cannot be arbitrary percentages or amounts. However, the manner in which reasonable indirect costs are determined is largely left to management.

Hence, there are two alternative methods which can be used as a basis for the distribution of indirect construction costs, when construction is carried out by the owner directly. The first, which may be termed the incremental cost method of ascertaining indirect construction costs, takes into account those costs that would not be incurred by the owner if there were no construction. The second is to distribute the indirect costs to construction, and to operation and maintenance on the basis of the actual proportions of time spent on construction and on operation and maintenance.

Engineering and supervision are well understood. These items of indirect construction costs are frequently combined in estimating because of the closely related nature of the charges.

Indirect labor charges and related expenses cover such indirect construction costs as:

1. Vacation pay.
2. Sickness.
3. Excused time.
4. Building and communication services.
5. Clerks and supervisors.
6. Maintenance of tools and equipment (where not included in direct costs).
7. Miscellaneous indirect labor costs (such as inspection and permit fees).
8. Social security, unemployment taxes, and so forth.
9. Workmen's compensation and liability insurance.

Insurance covers such items as fire insurance on camp buildings, construction facilities, and so forth, (when not otherwise allowed).

Taxes during construction comprise such taxes as general property, real estate, or personal property taxes levied on the facility under construction, during the period of construction, as well as payroll and sales taxes on labor and materials, and other applicable taxes, when not otherwise included in the estimates of investment costs.

Administrative and general expenses cover those administrative and general expense costs directly related to construction. In the distribution of indirect construction costs, according to the "Uniform System of Accounts for Electrical Utilities," after the facility is constructed, only those amounts of administrative and general expense which have a provable relationship to pertinent construction activities may be capitalized.

Interest during construction has been discussed under that head.

It has been previously indicated that the distribution of indirect construction costs should be made in keeping with the same procedure as normally followed by a particular owner's accounting practice. However, most estimators concerned with the preparation of estimates of investment costs used in the economic comparison of facilities will agree that the distribution of estimated indirect construction costs to the major components of a given facility is very much simplified, and without significant error, if the total indirect construction costs are allocated proportionately to the total estimated direct costs of the several components, in so far as such costs are used in estimating the proper depreciation charges for the several components. In actual practice, when the facility is constructed a slightly different procedure may be followed, but the one indicated seems to meet all requirements satisfactorily with a reasonable minimum of work.

TREATMENT OF RETIREMENTS

When the estimates of investment costs for use in the economic comparison of alternative facilities relate to entirely new facilities, rather than replacement of existing facilities due to retirement for one or more reasons, the case is quite straightforward. However, when the alternative facility involves the retirement and replacement of an existing facility, whether this partially or completely serves the same purpose as the new facility, the economic comparison obviously has to take into account an allowance for the facility being retired. In accordance with normal practice, particularly in the utility field, the amount involved would be the book value or undepreciated balance (or the depreciated balance, as the original value less depreciation is termed by some accountants) of the cost of the retired facility plus the cost of removal less the salvage value. This value must be treated as an additional cost in connection with the alternative facility. Otherwise the economic comparison would not be on a sound and logical basis, considering the significance of the decision to be made.

However, such treatment of retirements should afford little difficulty since the book value can be secured from the asset records, and the cost of removal and probable salvage value can be reasonably closely estimated.

GENERAL CONSIDERATIONS

OCCASIONALLY THE IDEA has been expressed that the economic comparison of facilities in the conventional manner is questionable when the dollar or other currency unit is depreciating consistently, as it has for so many years past. This leads to the consideration that the facility which has the longest life, even though the investment entailed is higher, may well be the cheapest in the long run. An instance in which this is of significance is an economic comparison involving hydroelectric and thermal-electric power projects, since a hydroelectric power development has a much longer life than a thermal-electric power plant, other things being equal.

The anticipated relative values of alternative complete facilities, after varying periods of years, may be included in their estimated investment costs in the form of a proportion of the investment cost termed present worth of the value of the facility at retirement. A retirement date, in one form or another, must always be assumed. That is, if a long-lived facility is compared with one of shorter life, or if financial policy dictates retirement of the investment in the long-lived facility in advance of the probable completion of its serviceable life, the investment in such long-lived facility should be credited with an amount equal to the present worth of the remaining serviceable life of such facility at date of the retirement.

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Westinghouse Completes Sound Laboratory for Noise Study

An anechoic chamber, for the study of noise, its source, cause, and measurement, has been built into a new sound laboratory by Westinghouse Electric Corporation in a suburban area of Pittsburgh, Pa.

Inside the main building and surrounded by masonry walls 12 inches thick, a 19- by 13- by 10-foot room has had its walls, roof, and floor completely covered with insulating material shaped in the form of wedges. These wedges are the heart of the anechoic chamber for it is their shape, composition, size, and number that determines the efficiency of the room. Fabricated from glass wool, each wedge is 8 by 24 inches at its base and 34 inches long. Wire mesh with 1/2-inch openings encases each wedge to facilitate installation and protect the easily damaged filler. A spring-supported wire net is stretched from all four side walls several feet above the wedges which cover the floor of the chamber. This platform will support equipment to be tested. Overhead, necessary types of service lines are available to operate the test pieces. Only the noise source and a microphone pickup are inside the room during tests; all gauges and recording devices are located on control panels in an adjoining room.

In the illustration at left, a technician is testing a tank-type vacuum cleaner for sound level in order that noise can be reduced or eliminated.

Load Pickup After Extended Outage

A. W. EDWARDS
MEMBER AIEE

L. V. CHABALA
ASSOCIATE MEMBER AIEE

ONE OF THE PROBLEMS facing utilities is that of restoring service after extended outages on heavily loaded distribution circuits. The accumulated demand which appears during an outage of more than 20 minutes quite often causes difficulty when re-energizing the line. The solution becomes one of breaking the system into segments which are then re-energized successively rather than all at once.

Generally, when re-energizing a system after an extended outage, the most serious part of the overload is that caused by the accumulated demand of automatic equipment which has switched to the start position during the outage.

This article describes the additions made to a standard sectionalizer to provide a low cost device for automatically breaking the system into segments and then progressively re-energizing these segments to lower the peak demand on the system during load pickup.

A solenoid mechanism is added to the automatic sectionalizer to close the main contacts of the switch when control voltage is applied.

A timing relay added to the automatic sectionalizer is equipped with contacts which close a predetermined time after voltage is applied to the relay. This action energizes the solenoid mechanism and closes the main switch contacts if they are open. If voltage is removed from the relay, the circuit to solenoid mechanism is opened after a 20-second time delay. Upon reapplication of voltage to the relay, the load pickup switch main contacts close after a predetermined time which is proportional to the time that power was off. This time is adjustable to a maximum of 30 minutes.

Studies of available literature indicate that a control relay which closes the load pickup switch in a time proportional to the time voltage was absent in the system would restore service with a minimum of outage time and still not cause excessive demand in the system.

The combination of elements listed results in a device which offers the following operation cycles.

1. If the load pickup switch is installed in a series circuit with reclosing equipment, and a permanent fault occurs beyond the switch, it will act as a normal sectionalizer, locking out if the fault is persistent. Any outage other than a persistent fault beyond the load pickup switch will not affect the switch.

2. If an outage is more than 20 seconds in duration, the timing relay will operate to open the closing circuit. If service then is restored, behavior of the switch and reclosing equipment depends on the loss of diversity or accumulation of demand that has taken place. Since the line contacts of the load pickup switch have remained closed, they will not open unless the system is overloaded enough because of loss of diversity and of inrush current to cause the reclosing circuit breaker to operate. If there are no reclosing operations of the reclosing circuit breaker, the main contacts of the load pickup switch will remain closed. When the timing relay contacts close at a later time, there will be no further action because the closing solenoid has not been tripped.

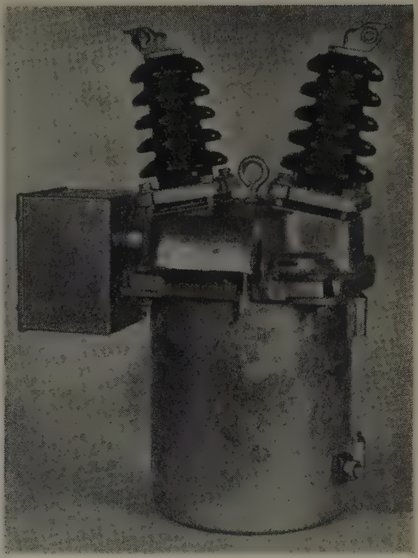


Figure 1. Load pickup switch. Over-all height 21 inches

Conversely, if there is enough overload to cause operation of the reclosing circuit breaker, the load pickup switch will lock out, using its sectionalizer functions, if it is carrying more than its tripping current. Due to the characteristics of the counter mechanism the main contacts will open as in sectionalizing operation, while no current is flowing. This disconnecting of load carried by one or more load pickup switches will allow the reclosing equipment to energize the remainder of the load without further operations. During the time required for the timing relay to close the load pickup switch, the diversity of the already connected load will have returned to the point where the load pickup switch may add its increment of load without causing the reclosing equipment to operate.

Momentary fluctuations in voltage will not affect the load pickup switch. Opening of the main contacts will be caused only by overloads, provided these overloads cause opening and reclosing operations of the feeder circuit breaker.

The load pickup switch is a device which can eliminate most of the time-consuming operations of recovering loads after extended outages, besides giving the same fault protection as a sectionalizer.

Digest of paper 52-143, "Load Pickup After Extended Outage," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. Not scheduled for publication in AIEE *Transactions*.

A. W. Edwards and **L. V. Chabala** are both with the Westinghouse Electric Corporation, East Pittsburgh, Pa.

Arthur Elmer Silver

Lamme Medalist for 1951

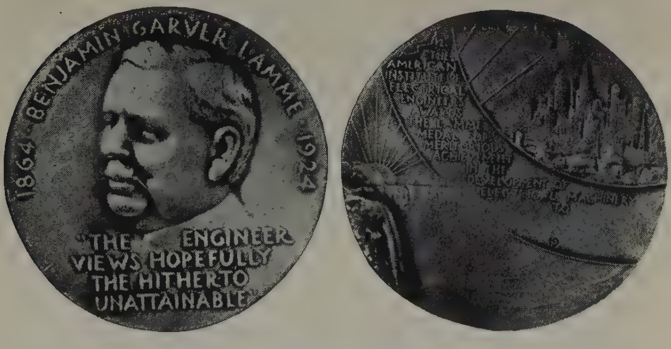
Arthur Elmer Silver, retired consulting engineer for Ebasco Services, Inc., has been awarded the 1951 Lamme Medal "for his pioneering of rural electrification by designing the simplified farm-type transformer combined with high voltage, long span, and common neutral line construction." Mr. Silver is the 24th recipient of the medal.

The Establishment of the Medal

A. H. KEHOE
FELLOW AIEE

THIS SESSION TODAY marks the 24th occasion at which our Lamme Medal has been presented to some member of the Institute. These awards have been made at consecutive Summer General Meetings of the Institute since 1929. All of them recognize some special "meritorius achievement in the development of electrical apparatus or machinery."

Over the years B. G. Lamme, the man and his attainments, have been well documented — both as an engineer and otherwise. During his career, he was awarded several medals, including the Institute's 1919 Edison Medal. On his passing he bequeathed three Lamme Medals, that is, two others in addition to the one we present today. While all three Lamme Medals make awards for engineering attainments, his heart must have been in our medal for this one alone is restricted to his chosen field of electric apparatus and machinery and is presented only to a member of the Institute which Lamme served so well.


BENJAMIN GARVER LAMME
1864
1924
THE ENGINEER VIEWS HOPEFULLY THE HITHERTO UNATTAINABLE
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The Lamme Medal, established 1926

All three Lamme Medals use a common obverse with the motto: "The Engineer views hopefully the hitherto unattainable." I believe anyone reviewing the 24 awards which have been made to date will agree that the recipients were imbued with that particular engineering virtue. While more than any other single type of attainment has been achievement in the field of rotating machines and associated slot forms for such machines, nevertheless, these awards do not make a majority, for such matter as instruments and relays and circuit interrupting or regulating devices each have had a number of awards. This year an important transformer development is acclaimed for the first time since 1931 when Giuseppe Faccioli received the medal for his contribution to bushing development for high-voltage transformers, capacitors, and arresters.

The field of the award has widened over the years as successive committees have reviewed the many developments of discrete equipment used in the electrical art. I believe we should "view hopefully" further expansion over the years. Greater attainments for us spell greater public well-being.

Career of the Medalist

CLAY C. BOSWELL
MEMBER AIEE

THIS IS ONE of the happiest occasions in which it has been my fortune to participate. It is a matter of keen pleasure and gratification to me, and to others who have known and been associated with Arthur Silver, to see his great contributions to engineering progress and to the advancement of techniques, practices, and equipment in the electric power industry, recognized by the award of the Lamme Medal. To me it is an unforgettable honor to take part in the presentation.

My first knowledge of A. E. Silver occurred in the middle teens, at which time I was employed by Utah Power and Light Company. It was there that Mr. Silver's original design of high-voltage substations with their major electric equipment outdoors was adapted to the severe winter conditions under which the 130-kv system of the Utah Company was operated. Because of its successful performance and marked relative economy, this basic outdoor design soon became widely adopted.

Beginning in 1923 and continuing for a number of years, I, as well as Mr. Silver, was employed by Electric Bond and Share Company. During all this period, I

Full texts of the presentation and acceptance addresses given at the Lamme Medal ceremony held during the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952.

A. H. Kehoe, Chairman of the Lamme Medal Committee, is Vice-President, Consolidated Edison Company of New York, Inc., New York, N. Y.

Clay C. Boswell is Vice-President and Assistant General Manager, Minnesota Power and Light Company, Duluth, Minn.; address presented by **F. S. Rice.**

ad a rather close contact with him, a contact pleasant at he time and one I am now happy to remember. By ersonal observation during that period, Mr. Silver was ver aggressive and imaginative, but equally important, e had the invaluable trait of being able to lead and irect others so that his group always performed as a vell-drilled team.

Since leaving the employ of Electric Bond and Share, ny present employer, Minne-ota Power and Light Com-any, has retained Electric Bond and Share Company nd, more recently, Ebasco Services, Inc., to do a great leal of electrical design work, ll of which was under Mr. Silver's direction until his etirement in 1948. It is ecause of this long associa-ion through the years that I feel justified in speaking out so positively concerning his man.

In telling you something about the career of the medalist, it is easy for me to outline some of his history and to enumerate some of his engineering accomplishments. But it is hard to do adequate justice to the outstanding quality of his leadership and vision that have been responsible in even greater measure than his engineering genius for the results that he has achieved.

A. E. Silver

Arthur Silver's boyhood was spent in an atmosphere of rugged existence in a settlement near Dexter, Maine, called Silver's Mills. This was his birthplace and here he encountered daily a procession of chores on the farm, in the saw mill that bore his father's name, and in the carpentry shop. At the tender age of three he displayed his affinity for things mechanical, by snatching a hammer from under the watchful but unsuspecting eyes of the carpenter who was laying a floor in the Silver home, and proceeding to drive nails in the floor in a manner fitting his own youthful ideas.

At one period of his early youth he earned spending money by raising and selling eggs at seven cents a dozen, and at the age of ten he was earning cash as well as a reputation among his boy companions by making and selling sleds. These were really rugged and serviceable, with iron "shoes" on the runners that Arthur hired a blacksmith to make for him.

Later, during his teens, he demonstrated mechanical skill of a high order by carrying out various projects of repair and improvement in and around the Silver saw mill. This included rebuilding the flume, welding massive log chains with improvised equipment, converting the log-feeding equipment to friction drive from an arrangement for meshing and unmeshing gears, and other projects equally difficult considering available equipment and methods of the time.

During his college years at the University of Maine he became imbued with things musical, beginning with the harmonica and soon making the college Mandolin Club and Glee Club. He became a member of the Phi Kappa Sigma Fraternity and was elected to the honorary fraternity, Phi Kappa Phi. He also made the track team and held the college record for 1/2 mile for several years. In passing, it may be noted that his physical stamina in later years has been outstanding, as many of his associates can testify, especially those who have had occasion to take long walks with him or engage in other physical exercise in company with him. Young Silver was graduated with honors from the University of Maine in 1902, with the degree of bachelor of science in electricity.

Immediately following graduation, he spent 2 years in the Testing Department of General Electric Company at Schenectady, N. Y., and then in 1904 entered the employ of Raleigh (N. C.) Electric Company in charge of meters. His duties were successively broadened until he was made Superintendent and Chief Engineer of Carolina Power and Light Company. This company's first high-voltage (60-kv) transmission line was constructed under his supervision.

Early in 1910 he was transferred to the Engineering Department of Electric Bond and Share Company in New York, N. Y., a holding company with a service organization in the utility industry. It was with this organization and its successor, Ebasco Services, Inc., that the full force of his genius and leadership came to be applied, and that the fruits of his labors came to be recognized and utilized by the power industry generally.

Here are some of his pioneering achievements.

In 1911 he designed and supervised construction of the first high-voltage substation having its major electric equipment installed out-of-doors (Method Substation of Carolina Power and Light Company).

In 1917–18 a preliminary design for a 220-kv transmission line was made. This was described in a paper he presented before the AIEE in 1919, 4 years before the first 220-kv line in the United States was placed in operation.

In 1926 he pressed the equipment makers for development of much needed lightning-measuring devices and technique. This led to the first field laboratory aimed at measuring directly the characteristics and dimensions of natural lightning, a co-operative project including Ebasco, General Electric, and Pennsylvania Power and Light Company. The first cathode-ray graph ever recorded of a direct lightning stroke was obtained in this laboratory on July 27, 1928. From this groundwork, rapidly taken up and expanded by others, including other members of the Ebasco family, the principles of lightningproof design were pretty well arrived at within a decade.

At about this same period he was responsible for the development of a specification for "self-protection" of high-voltage power transformers; that is, insulation strength on the exterior definitely proportioned to breakover before failure of interior insulation. This step initiated the industry-wide development of co-ordinated insulation levels for all lines and equipment throughout power systems.

In the 1920's he pioneered the development of practice and techniques for the utilization of primary voltages of the 11–13-kv class in general-purpose distribution systems, both urban and rural. This use of these voltages is now extensive and growing rapidly, yielding greater capacity, economy, and safety, and minimizing wire congestion on the streets, as compared to the lower primary voltages that have predominated in the past.

In 1936 he sponsored the redesign of the then cumbersome and costly static capacitor, for extensive application to power circuits. The subsequent extensive and industry-wide use of this device for releasing usable capacity in circuits and equipment is too well known to need mention.

Arthur Silver's interest in electrical service to farms and his contribution of consulting service to operating power companies, in the design and operation of farm lines, date back many years prior to his intensive attention to problems in this field that led to the development of the "farm-type" transformer. This intensive work was initiated at about the beginning of 1932 and under his guidance resulted in simplifying and reducing cost of distribution facilities for serving farms to the point where such service could be greatly extended economically. Farm line designs were produced which represented large reductions in cost and improvement in appearance over conventional designs in use at the time. Basic features of these designs received country-wide adoption and are widely used in present-day rural distribution. These features include multigrounded neutral, use of high-strength conductors for ultralong spans, and vertical arrangement of single-phase lines using pole-top insulator.

It would not be fitting to close this account without mention of Arthur Silver's work in industry committees and co-operative projects. He probably is better known for his leadership in this type of work than in some of his more direct engineering activities.

He was one of the leaders in the development, organization, and subsequent functioning of joint activities of the electric power and communication industries in the co-ordination of power and communication facilities. In this connection he served for many years until retirement as Edison Electric Institute (EEI) chairman of EEI–Bell Systems Joint Committee on Plant Co-ordination, and of EEI–Bell Systems Joint Committee on Development and Research. He was EEI chairman of a joint EEI–National Electrical Manufacturers Association committee in the development of the present co-ordinated and simplified design standards of distribution transformers.

I shall not attempt to enumerate his various memberships and chairmanships of industry committees which were many. Members of these committees who worked with Arthur Silver, one and all, have experienced unforgettably the force of his vision and leadership and have acknowledged his substantial contributions to co-operative progress. None of these, however, is more keenly aware than I of his genius, and the full measure in which he merits this award.

Pioneering and Development of Electrical Service to the Farm

A. E. SILVER
FELLOW AIEE

I AM DEEPLY MOVED by being chosen recipient of the Lamme Medal for 1951. I am indeed proud and grateful for this high honor, and accept it as a tribute to the contributions of those associated with me, as well as for myself.

This merit of accomplishment, it might well be said, grew out of the necessity of environs. The group of engineers that I was one of for so many years constituted a sector of the service staff of Electric Bond and Share Company, now Ebasco Services, Inc., which company came into being in 1905. It very soon took over interest in several struggling small electric power properties of Oregon and Washington that became the Pacific Power and Light Company. Similar steps were repeated many times in various parts of this country and elsewhere. Bond and Share, from the beginning, directed much effort to serving the rural areas. As late as 1936, approximately 85 per cent of communities served by the Bond and Share group of companies in this country had no more than 1,500 people. Bond and Share engineers worked closely with operating engineers in pioneering and developing farm service facilities. It was this occasion for leadership and the diligent support of my associates that brought about the accomplishments adjudged to merit the honor bestowed upon me.

As an engineer who has retired to the side lines, I beg indulgence while I look backward to review briefly farm electrification as I saw it grow and develop. So far as I know, it had its birth in 1898 on the system of Pacific Gas and Electric Company in California, with the application of electric power to pumping on irrigated farms. This pumping service soon spread to Oregon and elsewhere

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A. E. Silver, retired, was consulting engineer for Ebasco Services, Inc., New York, N. Y.

in the irrigated areas of the West. The experience which followed revealed many hurdles—technical, economic, and social—in the path of widespread farm electrification, but the movement had taken root and for the next two decades was nurtured and pioneered by the electrical companies.

Although lacking the impetus of irrigation pumping loads, farm service installations moved eastward to the Atlantic Coast. About 1910 promotional efforts near Poughkeepsie, N. Y., brought about the extension of a 2,500-volt circuit to serve 35 farms.

In this early stage, rural extensions were made to those farms that could be reached from city and town distribution systems. Progress was hard earned. It became recognized that urban practices did not fit the farm business. Underlying conditions were too widely different.

In an effort to correlate diversified experience data being produced in different parts of the country, in 1910 a Committee on Electricity in Rural Districts was organized by National Electric Light Association (NELA). It undertook industry-wide surveys, initiated contacts with agricultural colleges, appealed to the United States Department of Agriculture for dissemination of information on the use of electricity on the farm, and published a report in 1911 comprising probably the first systematic accumulation of data on farm electrification.

Following World War I, farm electrification was at the threshold of more consistent and extensive development. It had become clear that: 1. The cost of farm lines and utilization facilities must be reduced. 2. For profitable returns there must be substantial and increasing use of service by individual farms. 3. Co-ordinated effort in research, experimentation, and promotion on a larger scale than thus far undertaken was required, especially to develop equipment and appliances, both for the farm home and on the farmstead, that could be put to profitable use.

Grover C. Neff of Wisconsin Power and Light Company, chairman of NELA's Rural Lines Committee, was a persistent and forceful champion of this concept.

At the end of World War I it also became clear that co-ordination of effort among all groups interested in farm electrification was needed to speed progress. In August 1923, a Committee on Relation of Electricity to Agriculture (CREA) was organized by National Electric Light Association, American Farm Bureau Federation, American Society of Agricultural Engineers, Power Farming Association, and United States Departments of Agriculture, Commerce, and Interior. Other groups joined later.

Twenty-seven state committees were established to conduct and expedite experiments, the state agricultural colleges participating actively. In each of seven states a test project was built serving a typical group of farms. Large sums of money were expended in this experimental research, and the highly constructive results were compiled and circulated by CREA in bulletins and news letters.

Coincident with this CREA program the power companies stepped up activities. They organized rural service departments and sales campaigns were directed at the farm market by these companies, manufacturers, and electrical dealers. Engineering departments of the companies tackled the problem of developing lower cost distribution lines adapted to present and future needs of serving the farming areas.

The NELA Rural Lines Committee, in its Report for 1927, estimated that in another 10 years half the farms of America would have electrical service, and set as a goal an average annual use of 6,000 kilowatt-hours per farm.

I would like to elaborate somewhat on my earlier reference to Bond and Share's participation in fostering electrical service to the farms. The initial approach of its service staff, in common with others of the industry, was to fit farm service into the practices and facilities then in vogue in rural villages, the larger towns, and cities. Furthermore, any new cross-country line usually was built with capacity for meandering from one village to another in such respective order as service might be accepted.

As experience accumulated it was found that this approach was inadequate, and that practices more specific to the conditions of the farm areas must be developed. Two essentials to ultimate broad-gauge success in farm electrification appeared evident: co-ordinated over-all planning, and practical simplification of methods and facilities to minimize costs. This became company policy.

Idaho Power Company, then of the Bond and Share group, pioneered the important and far-sighted area basis of farm service extension. It developed co-ordinated sales, engineering, rate, and construction effort. Entire contiguous areas of its territory were surveyed and planned as units for eventual complete electrification. The area plan placed both construction financing and rate making on a community basis, avoiding more detail allocations that often operated to bar the small user. By 1928 this area plan was being actively prosecuted in the field.

For outstanding accomplishment in electrifying the farms in its territory, Idaho Power Company received the Charles A. Coffin award for 1935.

With attention directed to these more advanced objectives in farm electrification procedure, it fell to my division of Bond and Share engineers to design better suited and lower cost facilities. A fresh appraisal of service needs and of design possibilities brought these major criteria: an adequate supply of power, reasonably steady votalge, avoidance of interruptions of other than brief duration, safety, and maximum practical simplification of design for reduction of costs.

The area basis of planning gave a very productive approach to conservation of materials and labor. While backbone lines would be made adequate for future loads, nevertheless, by strategic locating, their mileage could be minimized. However, for the branch circuits to reach the large majority of individual farms a simple low-capacity line would be adequate. Because of its largely predominant mileage, design for this latter type of line received priority of attention. Poles, conductors, span lengths, and labor were the major factors determining costs.

Minimizing the number of wires to be carried was basic. A single-phase primary circuit from Y-connected supply with only one conductor on insulators, and this at pole top, was chosen. The neutral conductor, common to both primary and secondary needs, was clamped directly to the pole, and multigrounded for positive relaying and safety to equipment and persons. A low-cost farm transformer, described later, largely eliminated the justification for secondary wires on line poles.

Utilizing phase-to-neutral voltage of the 6.6–7.2-kv class, with branch circuit lengths under control, made practical primary conductors of moderate conductivity but high strength, and composed largely of a low-cost metal, steel. With such conductors, span lengths could be increased up to 600 feet normal and number of poles reduced by one-half or more.

In urban practice, poles of 7- to 8-inch top diameter with hardware for this size were usual. Well over half of this pole material was provided as a margin against future decay, for large numbers of these poles were without effective preservative treatment. The requisite farm-line strength would be provided by a 5-inch-top pole and effective treatment would preserve it for many years.

When considering the farm customer's service tap, the fact stood out that it was costing as much, or more, to provide the transformer and complete the customer's service installation as for a pro rata share of the line itself. This was the incentive for a simplified transformer installation. Several things were done in the design of the then conventional transformer, including: eliminating one primary bushing, connecting the neutral end of both primary and secondary windings directly to the tank interior, incorporating a simple spill gap from primary terminal to grounded tank for protecting transformer insulation from lightning, omitting winding taps, omitting terminal provisions for series-multiple connection of secondary coils, eliminating conventional hanger irons by interchangeable mounting directly to the pole. I presented these ideas for such a distinctly farm type of transformer to leading manufacturers, and was gratified by their hearty co-operation in working out details and making them available on the market.

While evident that circuit faults from lightning, spill-gap operation, and other causes must be accepted, it was fundamental that thermal damage and prolonged interruption therefrom be avoided. The objective of rapid fault clearing was then receiving much attention by utility and manufacturers' engineers generally. With increased relaying promptness and dependability from the multigrounded neutral, rapid clearing would provide reasonable protection of farm circuits from thermal damage.

Means to minimize duration of interruption were not immediately at hand. It had long been prevailing practice that a "tripped" circuit be left dead for one minute before re-energizing. Many engineers throughout the industry, dissatisfied with this delay, were furthering the principle of rapid automatic circuit breaker reclosing. That was adaptable to the farm circuits, but with the handicap that a permanent fault prevented restoration for the entire circuit. Our engineers studied this feature and in conjunction with experimentation on the system of Tennessee Public Service Company, then a Bond and Share property, developed co-ordinated fuse-breaker protection for automatically isolating the permanently faulted branch, and allowing automatic service restoration on the balance of the circuit.

All these farm-line design efforts, and others, by our engineers were carried along with the benefit of conference with engineers on operating properties and with their ready co-operation in trial application of recommended practices.

Now, speaking generally once more, in the early 1930's, the developmental era of extending electricity to the farms had reached maturity. The fruits of a decade of aggressive development activity growing from private central station initiative were: an adequate know-how generally, the area basis of procedure, minimized but adequate types of construction, the block rate system, and other proved practices, together with much better means for utilization of electricity on the farm and a growing farmer understanding of benefits from electrical service. The cost of service had been brought down by more than 35 per cent. Farms served with electricity had risen from 2.8 per cent of the total in 1923 to 12.5 per cent of the total in 1935, notwithstanding that this 12-year period embraced the severe business depression precipitated in 1929; also, farm income had been subnormal since 1920. Farmers as a whole had been in very difficult circumstances to undertake the expense of wiring and of purchasing appliances and equipment to put electricity to work.

At this juncture, a pronounced turn appeared in the course of farm electrification. Farm income and farm credit materially improved. The field so well prepared by long and diligent pioneering and developmental efforts of private industry was entered in May 1935 by the Rural Electrification Administration (REA), supported by large appropriations of funds to be loaned for the building of rural lines. The REA adopted almost unchanged the designs and construction practices developed and established by the private power companies. The two organizations together made rapid progress toward completion of the task.

Based on the 1950 United States Census count of 5,382,000 farms total in the United States of which about 268,000 were unoccupied, at the beginning of 1952 87 per cent of the total farms and 91 per cent of the occupied farms were served, and electrical service was available to 94 per cent of the occupied farms. REA co-operatives served about 50 per cent, investor-owned power companies served 44 per cent, and municipal systems, public utility districts, irrigation districts, and other local governmental bodies, served 6 per cent.

The service extension stage of the farm electrification movement, in just over 50 years from its birth, is now near practical completion. The engineering and construction problems of supplying power to the farms generally have been met satisfactorily. Of course, improvements and modifications to meet changing conditions will continue on indefinitely. The engineering art is not static, neither is the growth of America, and particularly rural America. I believe the basic engineering principles for farm service have been well established. The big job which now remains is to continue expanding the profitable utilization of electricity to attain maximum benefits from electrification for all. This sector of farm electrification, I am confident, still holds large potentialities for engineering endeavor. It is gratifying to note at the present time throughout the nation the effort concentrated on this phase of the work.

Short-Circuiting Techniques for Deactivating a Faulty Aircraft Generator

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When an aircraft self-excited d-c generator develops either a full-field short-circuit fault or a generator feeder fault, protection to the generator must be afforded. The method here described is the application of a short circuit between the generator output terminals thus disabling the power-generating capabilities of the machine.

AIRCRAFT ELECTRIC system protection has been stimulating much thought and activity during recent years. As operating voltage and output power have increased, so have their interruption requirements. There has been a tendency to increase the size of the interrupting device and, recently, to provide some form of backup protection. The deficiencies of most of these types of circuit protection are rather well known. There have been cases of generator contactor failure caused by insufficient arc-interrupting capacity or contact welding. Even with normal contactor operation during faulted conditions, there have been no means to de-energize the generator completely for all types of faults. Those responsible for the aircraft electric systems generally have recognized the desirability of providing protection equipment for a self-excited d-c generator which, after a full-field short-circuiting fault, would reduce the generator terminal voltage to zero, or, after a generator feeder fault, would reduce the current output of the machine essentially to zero. Presently available equipment and circuits do not provide assurance of this type of protection.

No attempt has been made herein to discuss the sensing of the fault; this is considered an independent and adequate entity. Also, no attempt was made to use this short-circuiting technique with paralleled generators, since, if sensing has been correctly utilized, it may be assumed that the sensing device has detected the faulted condition and has selected the proper generator for deactivation.

THEORY OF OPERATION

PREVIOUS PROTECTION arrangements have been inadequate for the following two types of faults:

1. *Full-field short-circuiting fault.* A full-field fault will allow complete shunt-field excitation after all control circuits have been opened.
2. *Generator feeder fault.* A generator feeder fault will permit heavy currents to feed the fault continuously when there is sufficient current in the series field to provide the required internal flux.

In both cases the power loops remain closed, even after disconnections have been made between the generator and the main bus, presenting a possible continuous hazard.

To control a generator after such faults, its internal magnetic flux should be reduced to the point where no electric power can be generated. The first attempt to reduce excitation during overvoltage was made by purposely connecting a short circuit across the shunt field to by-pass the field current. This idea of purposeful short circuits then was extended to the other generator terminals (or their extensions) singly and in combinations for more complete control. These short circuits, together with adequate circuit preparations, by-pass the currents that allow the continuation or secondary build-up of internal flux. Four types of purposeful short circuits may be considered for control of the faulted system:

1. *Shunt-field short circuit.* To provide a shunt-field short circuit, the field circuit between the short circuit and the generator bus first must be open-circuited. The short circuit then will provide a by-pass for current which might flow through the shunt field during a full-field short-circuiting fault. During other types of faults, the short circuit will provide a field-energy discharge path, substantially helping other simultaneous actions in reducing terminal voltage. Such a short circuit, by itself, cannot reverse the residual flux of the generator.

2. *Armature short circuit.* An armature short circuit can very easily carry armature current past the breakdown point on the external characteristic of the generator and near its point of zero terminal voltage.[1] The self-excited generator cannot continue to supply excitation under such conditions. The actual transient currents during application of the short circuit are determined by the field flux conditions during that period and the transient opposition to that flux created by the demagnetizing component of the armature magnetomotive force. If there is not sufficient original flux, the short-circuiting current, under certain conditions, can produce enough demagnetizing component together with the circuit inductivity to reverse the residual flux of the generator.

Before this armature short circuit can be applied, the circuit between the generator and other paralleled sources of power must be conditioned so that no power, or only a little predetermined amount of power, can be fed back to the short circuit from these other sources. This require-

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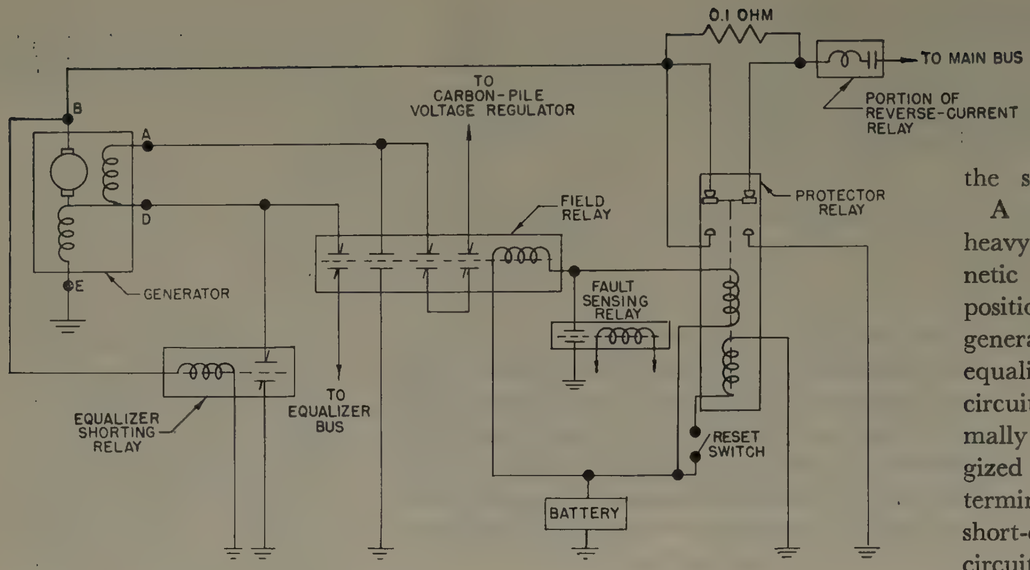

Figure 1. Schematic diagram of circuit used for generator control after a fault

ment can be met with a contactor which opens the circuit between the short circuit and the main bus. A resistor placed across the contacts of this contactor will decrease the current to a value which will allow, after completion of the short circuit, for the proper operation of the reverse-current relay normally used with the system.

3. *Generator feeder-to-ground short circuit.* A generator feeder-to-ground short circuit essentially accomplishes the effect of the armature short circuit and requires the same circuit preparation. The difference lies in that the short-circuiting currents now flow through the different series-connected windings of the machine as well as the armature itself. These windings limit the flux distortion caused by armature current and also contribute to the in-line shunt-field flux, thus completely avoiding the possibility of reversed residual flux.[2] This short circuit, alone, can permit the generator current to maintain itself above approximately mid-speed.

4. *Negative-brush-to-ground short circuit.* The generator equalizer (or paralleling) terminal, which is internally connected to the negative brush of the machine or to a point close to the negative brush, is generally brought out as an external terminal. A short circuit from this equalizer terminal to ground will by-pass an effective proportion of the current flowing through the series-connected windings. If this short circuit is accomplished after the generator feeder-to-ground short circuit has been completed, it will by-pass sufficient current to avoid current self-excitation of the machine so that the short circuits will not be fed with power after the initial transient. The equalizer bus should be properly disconnected from the generator during and after the control process.

TEST METHODS

A 30-VOLT 300-ampere wide-speed-range d-c generator, together with an appropriate regulator, reverse-current relay, and additional components to provide the various purposeful short circuits after fault detection, furnished equivalence to an aircraft electric system. This system is shown in Figure 1. It was used throughout the tests for generator control after the faults had been sensed or after the sensing had been simulated.

A 2-coil protector relay with heavy contacts and having a magnetic latch in its normally closed position was used for the purposeful generator feeder short circuits. The equalizer-terminal-to-ground short circuit was accomplished by a normally closed relay which was de-energized by a reduction in generator terminal voltage. Opening and short-circuiting of the shunt-field circuit was achieved by a field relay with contacts as shown in Figure 1. Thus, three separate relays were used to accomplish these purposeful short circuits. It is possible and desirable to combine their individual functions into the protector relay with proper time-sequencing of the contacts which perform the circuit preparations and purposeful short circuits.

Full-field short-circuiting faults were sensed by an overvoltage relay. Generator feeder faults and detection were simulated, with control occurring approximately 50 milliseconds after the fault was applied.

RESULTS AND DISCUSSION

THE SEQUENCE OF circuit and relay operation once the fault has been sensed is indicated by the encircled numbers shown in Figure 2. The millisecond values specified are applicable to good circuit and generator protection after a fault, utilizing the techniques discussed.

Representative conditions encountered in the operation of an aircraft electric system were selected. Oscillograms of these conditions were taken in successive order and are shown in Figures 3, 4, and 5. Figure 3 shows the circuit condition obtained after a full-field fault. Values of 6,000 rpm and a 150-ampere load were selected to simulate cruising speed with normal generator loading. At the

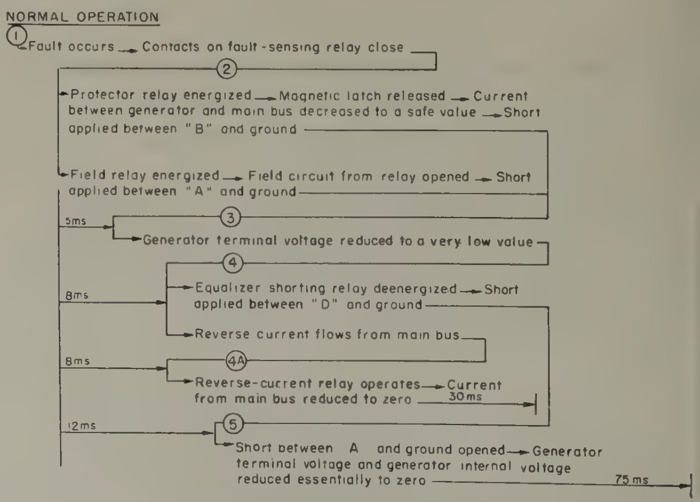
NORMAL OPERATION
① Fault occurs → Contacts on fault-sensing relay close
②
Protector relay energized → Magnetic latch released → Current between generator and main bus decreased to a safe value → Short applied between "B" and ground
Field relay energized → Field circuit from relay opened → Short applied between "A" and ground
5ms
③
Generator terminal voltage reduced to a very low value
④
8ms
Equalizer shorting relay deenergized → Short applied between "D" and ground
Reverse current flows from main bus
8ms
4A
Reverse-current relay operates → Current from main bus reduced to zero
30ms
12ms
⑤
Short between A and ground opened → Generator terminal voltage and generator internal voltage reduced essentially to zero
75ms

Figure 2. Relay and circuit operational sequence from a fault

instant that control of the fault was started, 930 amperes were flowing into the bus at 47.5 volts. Within 2 milliseconds the high current between the generator and the bus was interrupted and the bus voltage was reduced to 28.5 volts. In that same time, generator voltage was reduced to 3 volts and generator current increased to 1,530 amperes. In 107 milliseconds, generator current and terminal voltage were reduced essentially to zero.

Figure 4 shows a possible extreme in generator terminal voltage with a full-field fault at 9,000 rpm. At the instant that control of the fault was started, the generator terminal voltage was 113 volts. Within 2 milliseconds, this voltage was reduced to below 4 volts and the generator current increased to 1,800 amperes. In 100 milliseconds, the generator voltage and current were essentially zero.

Figure 5 shows the transient during a 300-ampere simulated bus fault. During its 43-millisecond period, this fault was intended to represent, in an integrated sense, much higher intermittent peak currents obtained during an arcing fault. At the instant that control of the fault started, the total generator current was 450 amperes. Within 2 milliseconds, the generator terminal voltage was reduced to less than 3 volts, and the generator current increased to 1,080 amperes. In 80 milliseconds, the generator voltage and current were essentially zero.

Similarities in these oscillograms and other oscillograms taken during this investigation indicate the following:

1. Within a few milliseconds after the fault-control action started, the generator terminal voltage was reduced to below 5 volts and, within 100 milliseconds, was reduced further to a negligible value.

2. The generator currents created by the purposeful short circuits during fault control started with an initial transient peak between 1,000 and 2,000 amperes and were reduced essentially to zero in 100 milliseconds.

3. The bus-voltage transient after fault control started was negligible.

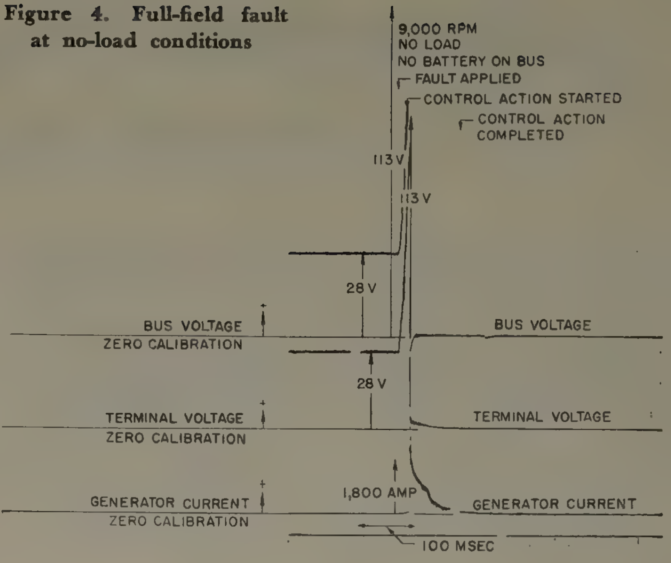
Figure 4. Full-field fault at no-load conditions

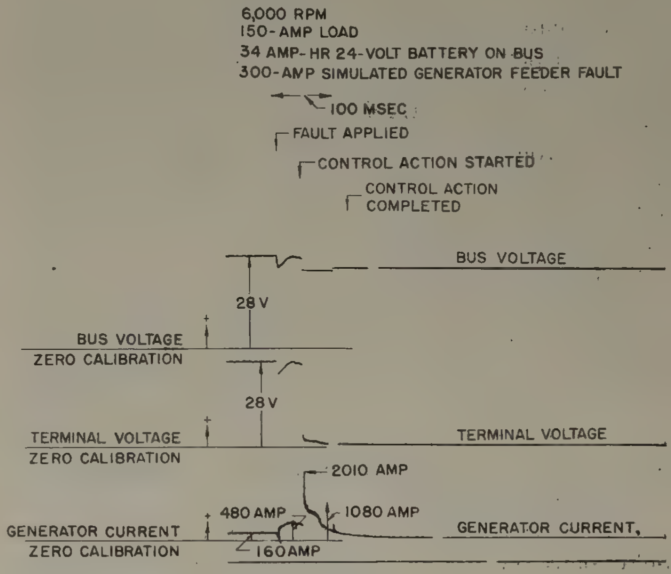

Figure 5. Simulated generator feeder fault

CONCLUSIONS

1. There has been no recognized method of completely deactivating an aircraft self-excited d-c generator after a full-field short-circuiting fault or a generator feeder fault.

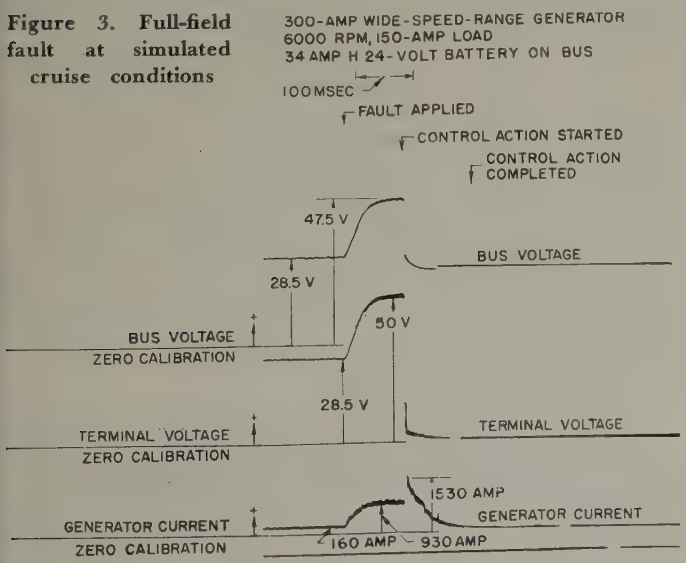
Figure 3. Full-field fault at simulated cruise conditions

2. The presented short-circuiting technique, applied to the control of a generator after such faults, is effective and provides assurance that the internal flux of the machine can be adequately reduced when full-field or generator feeder faults occur. It is adaptable to other types of faults.

3. This control technique is much safer than previous methods used to deactivate the aircraft generator and imposes less strenuous requirements on protective equipment and on their limits of operation.

4. These short-circuiting techniques may provide extremely rapid control as illustrated in Figure 2.

5. Proper sequencing necessary for complete protection can be arranged for all control applications within one relay device.

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Impulse Corona Detection and Measurement

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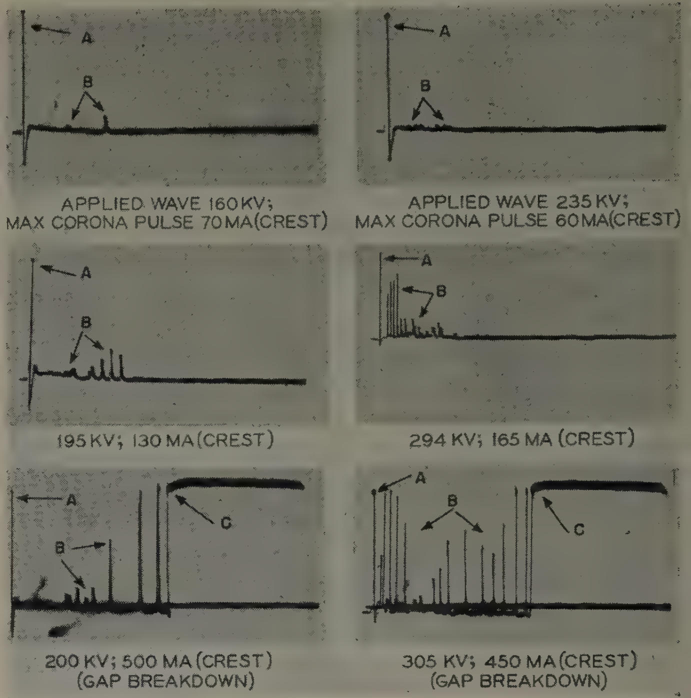
CORONA AS DEFINED HERE is an ionization in any insulating media and in any form of discharges that result in a partial breakdown of the insulation accompanied by a loss of some electric energy in the system. In particular, impulse corona is defined as corona that is caused by an impulse voltage such as a 1.5x40-microsecond wave.

Detection of impulse corona is accomplished by current measurements in a bridge circuit of a capacitive-resistive type as shown in Figure 1. The circuit consists of a corona-free capacitor C_1, a capacitive-type test piece C_2, and resistances R_1 and R_2 for equalizing the time constants of the two capacitive branches. With proper circuit constants this permits balancing out the capacitive-charging currents, which for many samples have amplitudes of several hundred to several hundred thousand times those of the corona currents. If the charging currents are balanced perfectly, the detector then measures any voltage difference between points *A* and *B* which will be caused by corona currents in branch 2.

In practice, perfect balance cannot be obtained in high-voltage circuits due to imperfect shielding and differences in lead length, and therefore a voltage spike appears on the front of the 1.5x40-microsecond wave. This is useful as a time marker. Since the shape of this unbalance remains constant with increase of applied voltage, corona pulses occurring during this period can be discovered by wave-shape comparison.

The present instruments permit detection of corona pulses of as low as 1/3 milliampere. Experience has shown that this sensitivity is sufficient to detect corona-starting currents for most types of electrodes and insulating media.

The type of corona pulses occurring in oil are illustrated by Figure 2 for point-to-plane gaps in oil at positive and negative polarity. The discrete pulses have about the same shape and duration, of the order of 1 microsecond, for both polarities. However, the number of pulses and their distribution over a given time interval are radically different for the two cases. The process in both cases seems to be by streamer propagation and the difference in pulse frequency and pulse pattern may be due to space-charge phenomena, which must be different for the two polarities.



APPLIED WAVE 160KV; MAX CORONA PULSE 70MA(CREST)

APPLIED WAVE 235KV; MAX CORONA PULSE 60MA(CREST)

195KV; 130MA(CREST)

294 KV; 165 MA (CREST)

200 KV; 500 MA (CREST) (GAP BREAKDOWN)

305 KV; 450 MA(CREST) (GAP BREAKDOWN)

Figure 2. Corona pulses from point-to-plane gap in oil, spacing 4 inches, 1.5x40-microsecond wave applied to point, plane grounded; (left) point positive, (right) point negative; (A) start of wave, (B) corona pulses, (C) gap breakdown; sweep duration 100 microseconds

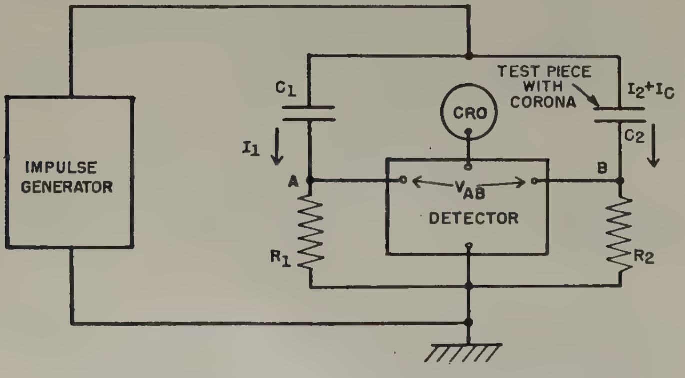


Figure 1. Diagram of the impulse corona detection

The electrical method of corona measurement can detect corona in structures when visual observation is impossible. It is applicable to any kind of capacitive test specimens consisting of two electrodes with various insulating structures between them. Such specimens include practically all component parts of insulation in transformers, such as insulation between windings, coils and turns, cables, bushings, and others. The information obtained on such samples can be applied to design of the finished product with full confidence that no damaging corona will exist. In many cases the shape and polarity of the pulses observed on the cathode-ray oscillograph are indicative of the condition of solid insulation within the test specimen after corona occurred as to entrapped gases, tracking, carbonization, and partial puncture.

Digest of paper **52-105**, "Impulse Corona—Detection, Measurement of Intensity, and Damage Produced," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Broad-Band Coupling Unit for Power-Line Carrier With Associated Potential Device

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The aperiodic coupling unit and potential device described here have a performance that substantially exceeds the minimum requirements set forth in the AIEE Standard Number 31. Their use also eliminates several difficulties present in the conventional installation.

THE USE OF high-voltage power transmission lines for propagation of carrier signals for point-to-point communication requires efficient transfer of energy from the transmitter to the power line and from the power line to the receiver. Signals of a few millivolts at the carrier frequency must be separated from a circuit upon which is also impressed 60-cycle energy at a potential up to several hundred thousand volts.

Many different schemes have been used in past years to couple carrier equipment to high-voltage power lines. One of these was antenna-type coupling, in which a conductor connected to the carrier equipment is mounted on the transmission-line structures and parallel to the phase conductors for distances as long as 1/2 mile. However, the coupling efficiency is relatively low, the radiation is high, and coupling and tuning vary with conductor swing in this type of system.

Another type, known as inductive coupling, used an extra winding in a power transformer, but here again the coupling efficiency at carrier frequencies was relatively low, the cost high, and the application limited.

Quite early in the development of carrier-current systems the paper capacitor became the accepted standard carrier-coupling device. Its characteristics are permanent, and it lends itself readily for use in measurement of the 60-cycle potential on the line as well as for carrier coupling. The capacitors usually are made up of a large number of sections connected in series to attain the desired voltage rating. To insure uniform quality, a set of test standards has been set up as AIEE Standard Number *31*, "Outdoor Coupling Capacitors and Capacitance Potential Devices."

For convenience in installation in the steel structure of a substation, the capacitor units usually are mounted on a metal base. Higher voltage units are made up by stacking capacitor units in series on the same base unit. The base unit also contains protective gaps and a grounding switch.

In a typical installation, the upper end of the capacitor is connected to the power-line conductor. An inductance with a low 60-cycle impedance and a high carrier-frequency impedance is connected from the bottom terminal of the capacitor to ground to provide a path for the 60-cycle current flowing through the coupling capacitor.

For carrier coupling, it would be most desirable to make the capacitor value sufficiently large so that it would have negligible reactance at the carrier frequencies. This, however, is not an economical approach. The usual arrangement is to use a smaller value of capacitance and tune out its reactance with a suitable inductance.

The simplest application involves the coupling of a single frequency between a single line conductor and ground using a single coupling capacitor. The basic circuit of this coupling system is shown in Figure 1. The coupling capacitor is series resonanted with a single variable inductor at the operating frequency of the carrier set. This provides an efficient path for coupling the carrier signal to the line conductor. The carrier equipment is matched to the apparent impedance of the power line by means of the adjustable transformer shown. For single-frequency applications this is an entirely satisfactory system.

However when more than one frequency must be coupled to the circuit, a more complicated network must be used. A typical 2-frequency system is shown in Figure 2. Each branch of this network contains an antiresonant circuit tuned to the frequency which the opposite branch is carrying. Adjustment is more involved and must be made in a prescribed order to prevent interaction between the

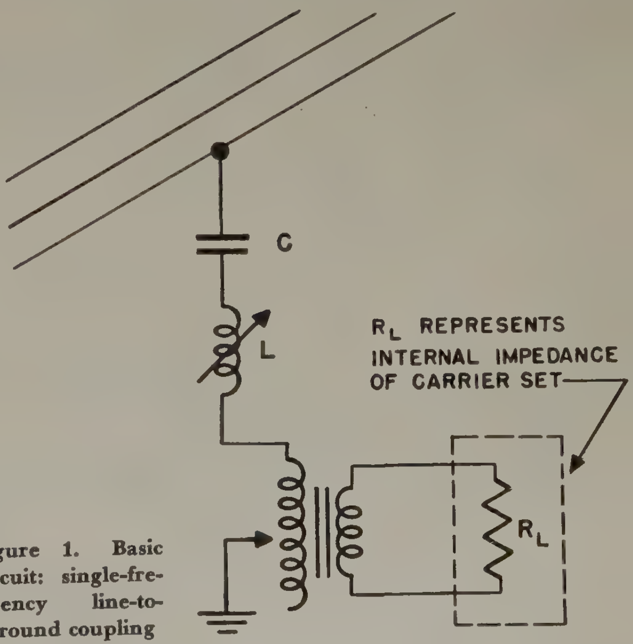

Figure 1. Basic circuit: single-frequency line-to-ground coupling

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Essentially full text of paper **52-153**, recommended by the AIEE Committee on Carrier Current and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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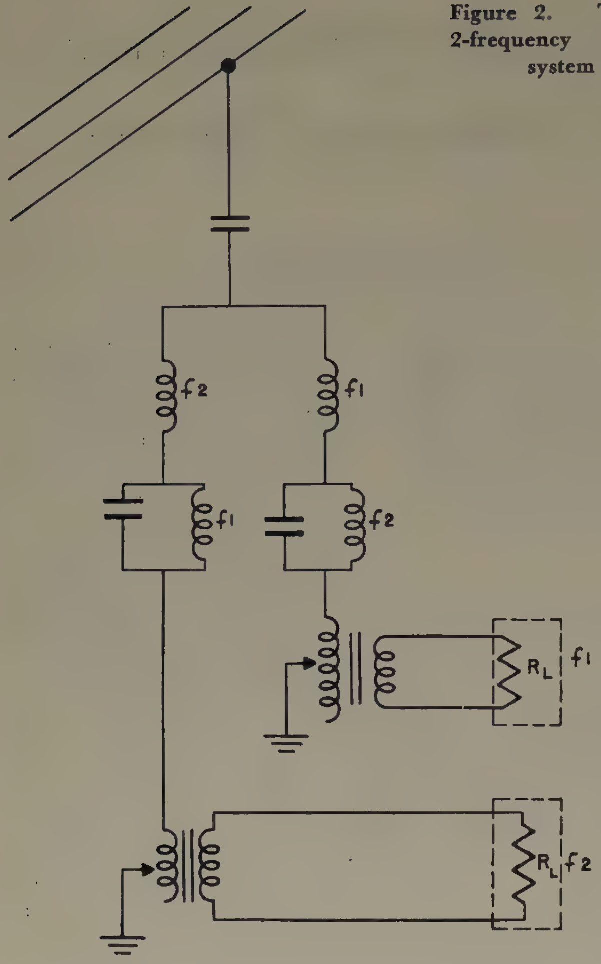


Figure 2. Typical 2-frequency tuning system

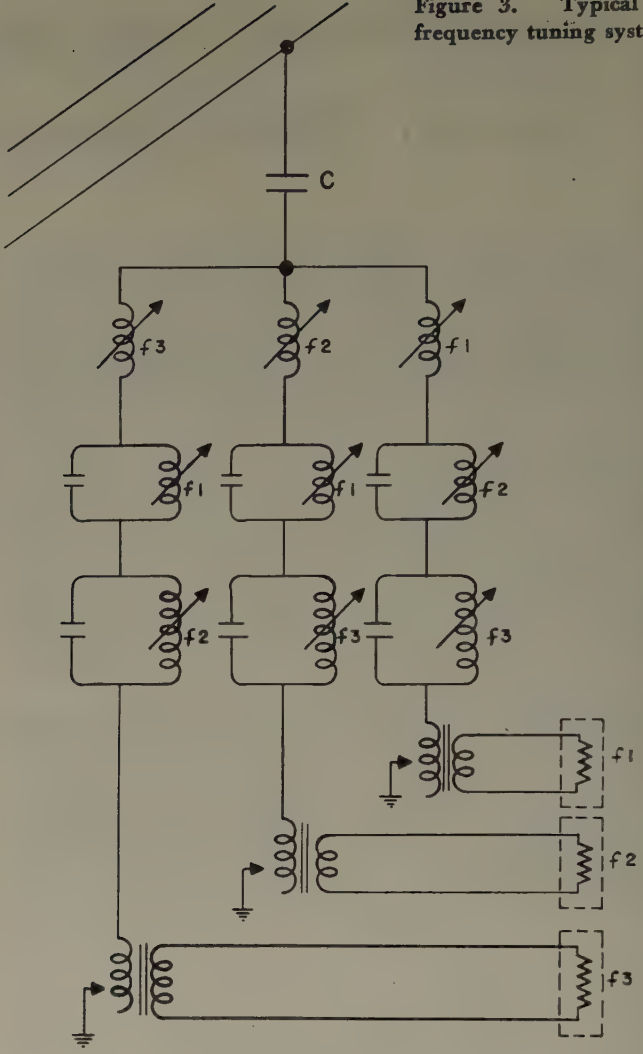


Figure 3. Typical 3-frequency tuning system

tuning controls. Additional losses also are introduced in each circuit due to the added elements.

A typical 3-frequency tuner is shown in Figure 3. Here each branch contains antiresonant elements tuned to the frequencies carried by the two other branches of the circuit. This network contains more than twice as many circuit elements as the 2-frequency tuner and the losses incurred in this type of network almost reduces to the vanishing point the economical advantage of putting multiple frequencies through a single coupling capacitor.

More important than this, however, is the little considered point that a circuit containing a large number of reactive elements has a number of antiresonant and resonant points in addition to those for which the circuit is normally designed. Foster's Reactance Theorem provides that the transfer characteristic of a circuit plotted with respect to frequency, when measured from any one of its driving points, shall have a number of nodes and poles equal to one plus the number of reactive elements in the circuit.

A triple-frequency problem, encountered in the field, required that the exact tuner shown in Figure 3 for frequencies of 50, 67, and 160 kc be built. Figure 4 is a plot

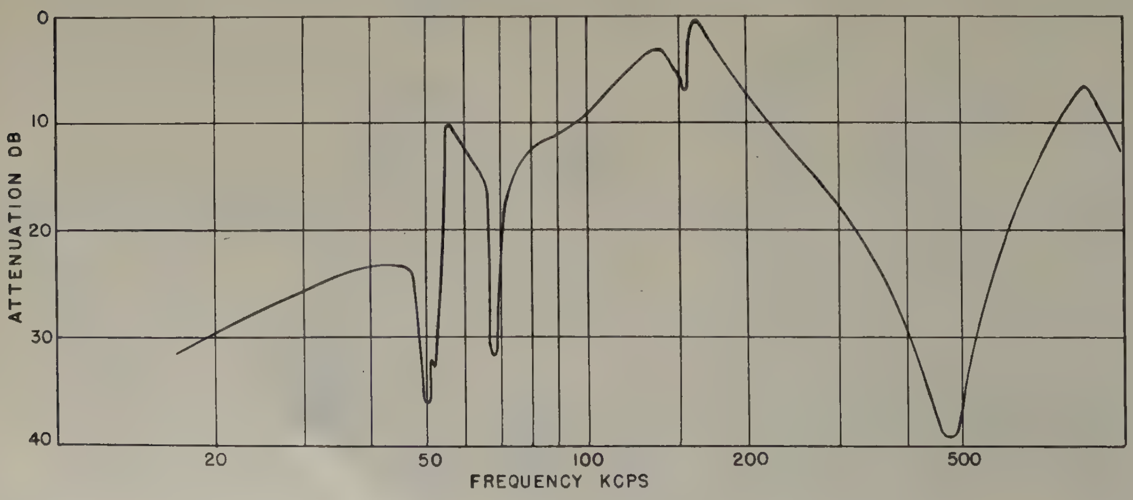


Figure 4. Transfer characteristics: 3-frequency tuner 160-kc channel (50, 67, 160 kc)

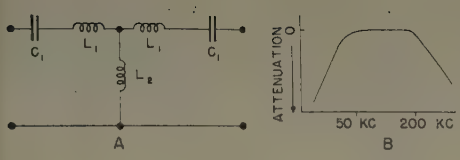


Figure 5. Single-section band-pass filter

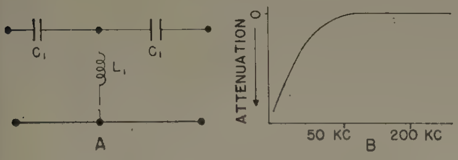


Figure 6. Single-section high-pass filter

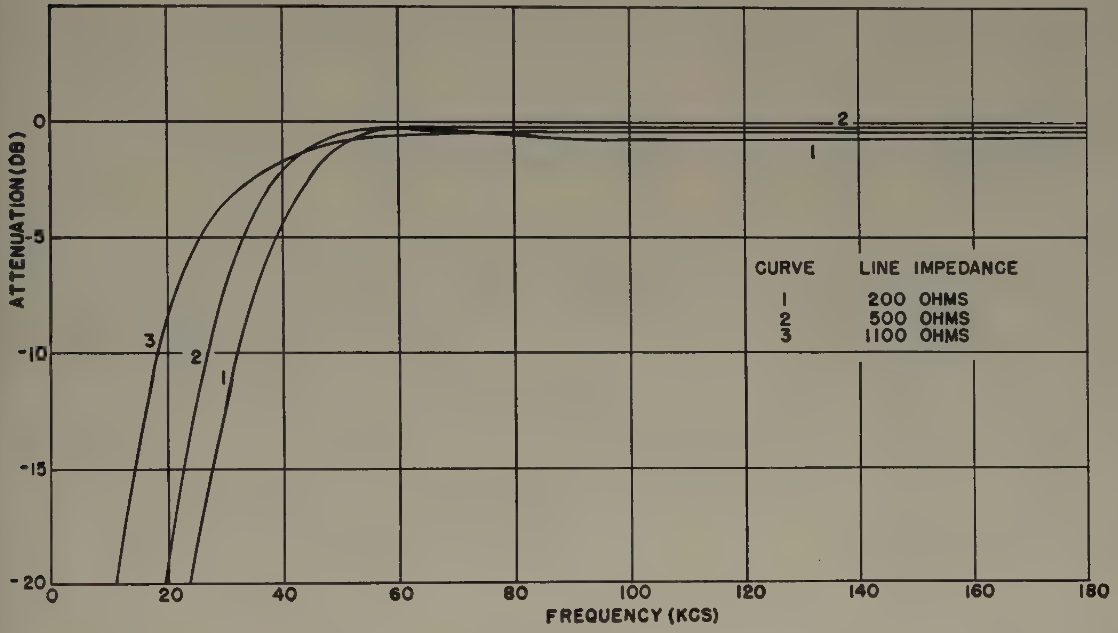


Figure 7. Frequency response characteristics: 69-kv aperiodic line-coupling unit

of the transfer characteristic of this tuner when considered from the point of view of the 160-kc channel.

Extra acceptances are shown at approximately 56 and 850 kc which might well admit undesired signals into the front end of the carrier receiver. Several additional antiresonant points are shown. In this case, the most troublesome one occurred at 156 kc, which was very near the 160-kc frequency which the tuner was intended to pass. The phase characteristic of this tuner in the passband centered around 160 kc resulted in serious distortion because of sideband cancellation.

The most alarming part of the problem is that the positions of the extra nodes and poles produced in this sort of tuner change rapidly with the inductance capacitance ratios of the various circuit elements, and their locations cannot be predicted accurately ahead of time. Under one condition of tuning, the antiresonant point shown at 156 kc fell at 158 kc, which was very close to the carrier frequency of 160 kc. Under this condition, the circuit was unusable.

BROAD-BAND COUPLING

The problems encountered in the conventional system of tuning have prompted the development of the broad-band coupling units described in this article. It was desired to develop a coupling system, using a single coupling capacitor, which would provide an efficient connection to the power line for a large number of transmitters and/or receivers operating in the 50- to 200-kc region. Such a coupler also would provide an ideal unit for multifrequency by-passes and for multiline interconnections.

When the engineer considers broad-band networks, he looks immediately to filter theory. For carrier applications he has the choice of either band-pass or high-pass sections. Several band-pass sections are applicable to this problem, where one element of the section can be used as the coupling capacitor. The most promising is shown in Figure 5*A*. In order to pass the general carrier band, cutoff frequencies of 50 and 200 kc were chosen. Conventional filter design equations apply and show that for a nominal line impedance of 500 ohms, the component values are as follows: $L_1=0.133$ millihenry; $C_1=0.0048$ microfarad; and $L_2=1.000$ millihenry. This circuit possesses the transfer characteristics shown in Figure 5*B*.

A typical high-pass filter section having a cutoff frequency of 50 kc is shown in Figure 6*A*. For a nominal line impedance of 500 ohms, the component values are: $C_1=0.0064$ microfarad; and $L_1=0.80$ millihenry. The transfer characteristic of this circuit is shown in Figure 6*B*.

Both of these circuits provide the type of coupling desired. The power transfer efficiency of both is extremely good,

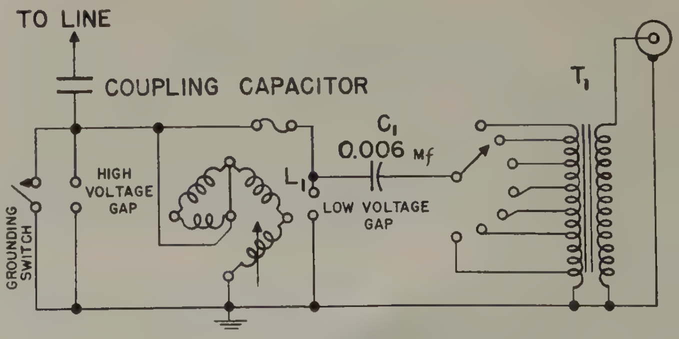


Figure 8. Aperiodic line-coupling unit

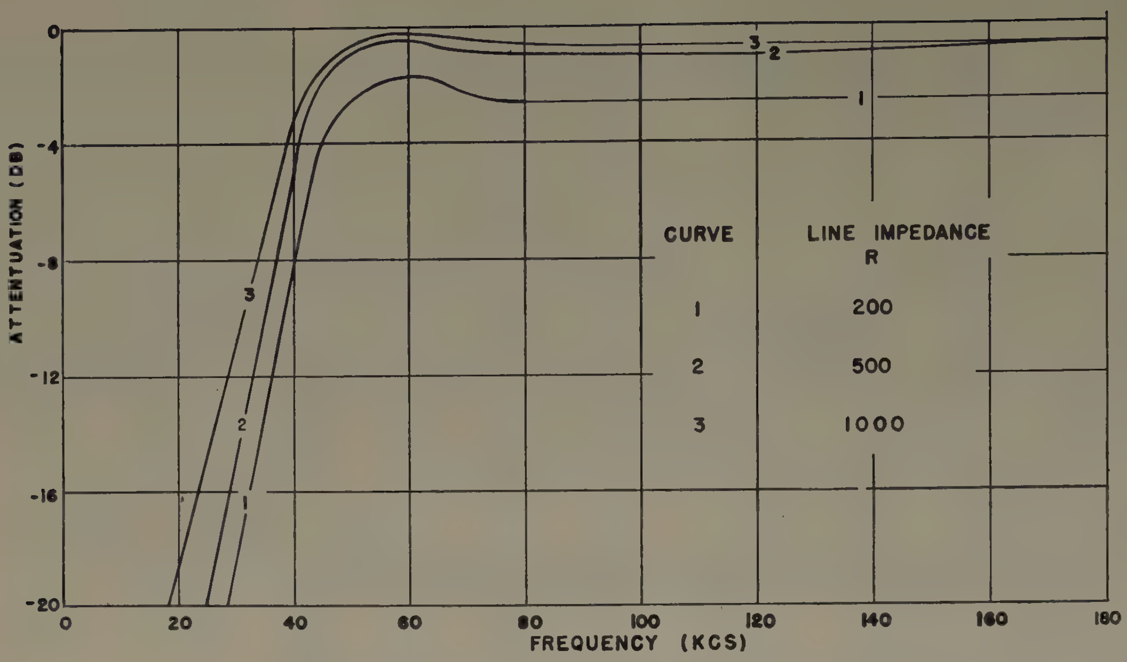


Figure 9. Frequency response characteristics: 138-kv aperiodic line-coupling unit

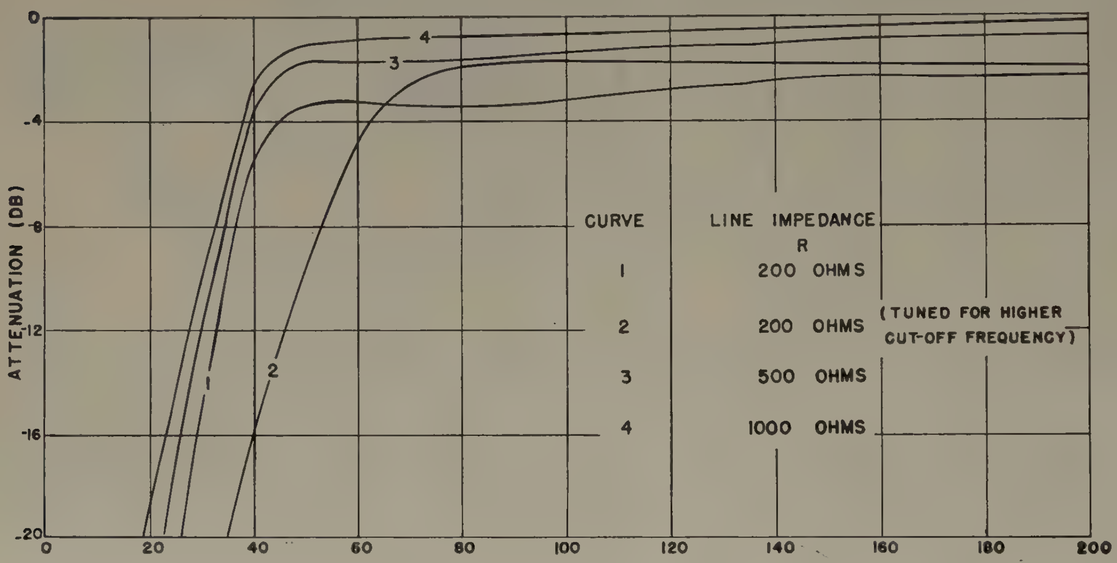


Figure 10. Frequency response characteristics: 230-kv line-coupling unit

and the values of C are commercially practical for carrier-current coupling capacitors.

The high-pass section shown in Figure 6*A* was chosen for the final design on the basis that it contained the least number of elements requiring adjustments to match a typical line condition. Only the mid-shunt arm of this filter was made adjustable to match a wide range of line impedances satisfactorily.

A plot of the transmission characteristics of a 69-kv aperiodic coupling unit is shown in Figure 7. Curve *2* shows the performance curve when matched to a typical transmission line of 500-ohm impedance. Since this is a single-section filter unit, only slight modifications of the usual curve are experienced for impedances of more than twice or less than half of this value. Curves *1* and *3* show the same unit when matched into 200 and 1,100 ohms, respectively.

It is important to note that for all frequencies greater than 50 kc, the design cutoff, the transfer loss of this coupler is less than 1 decibel.

Figure 8 shows the complete circuit of the aperiodic line-coupling unit.

The 69-kv capacitor unit is made up of 80 sections in series of the highest quality paper dielectric elements. These are mounted within a porcelain bushing, impregnated with a high quality mineral oil, and hermetically sealed to appropriate end plates. The capacity of this unit is 0.006 microfarad. A 34.5-kv unit is made up of 40 sections in series identical in construction with those used in the 69-kv unit. These are mounted in a shorter porcelain bushing. The capacitors are designed to meet conservatively all requirements of AIEE Standard Number *31*, and appropriate production tests are applied.

The capacitor unit is mounted on a welded steel pedestal base, which also contains the remainder of the circuit elements required for the coupling unit. The usual grounding switch is included and arranged for operation with a standard hot-stick.

The tuning inductance in this coupling unit also serves as the 60-cycle drain coil. This coil has a much lower inductance than the usual drain coil and hence can be made of larger size wire. Drain coil openings due to corrosion are thereby practically eliminated. Low- and high-voltage gaps and a 10-kv fuse are included to provide protection to personnel and equipment.

A heavy duty mica capacitor completes the filter section. The matching transformer is made adjustable to allow any transmission-line impedance from 100 to 1,100 ohms to be matched conveniently to a 50-ohm coaxial cable leading to the carrier set.

It was found also that the main coupling capacity could be changed a considerable amount from the nominal value without seriously affecting its applicability as a carrier coupling unit. This permits the usual stacking of coupling capacitor sections for higher voltage operation. The values of the coupling capacity are shown as follows for various line voltages:

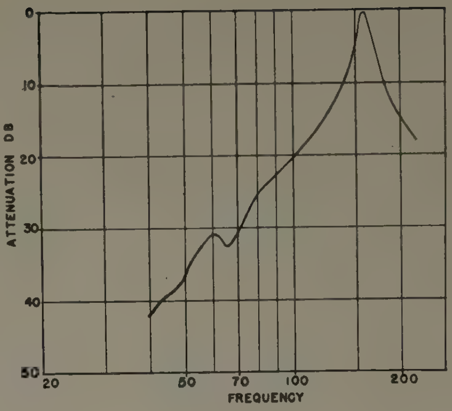
Voltage, kv	Capacity, μf	Voltage, kv	Capacity, μf
34.5	0.012	138.0	0.003
69.0	0.006	161.0	0.0024
115.0	0.004	230.0	0.002

The higher voltage units are made up of 34.5-kv units and 69-kv units mounted in series.

Transfer characteristics of a 138-kv unit are shown in Figure 9. This shows that for the same impedances, the characteristics are quite similar to the 69-kv unit.

Figure 10 shows the transfer characteristics of a 230-kv unit. In spite of the deviations from the design value of capacitance in the coupling capacitor, the attenuation is less than 4 decibels for all frequencies above the cutoff value. This is still more efficient than a conventional coupling system, when tuned for three or more frequencies. Many tuning conditions are possible; curve *1* illustrates another tuning option for this unit, when it is desired to

Figure 12. Transfer characteristics: aperiodic line-coupling unit and 3-line matching units 160-kc channel (50, 67, 160 kc)



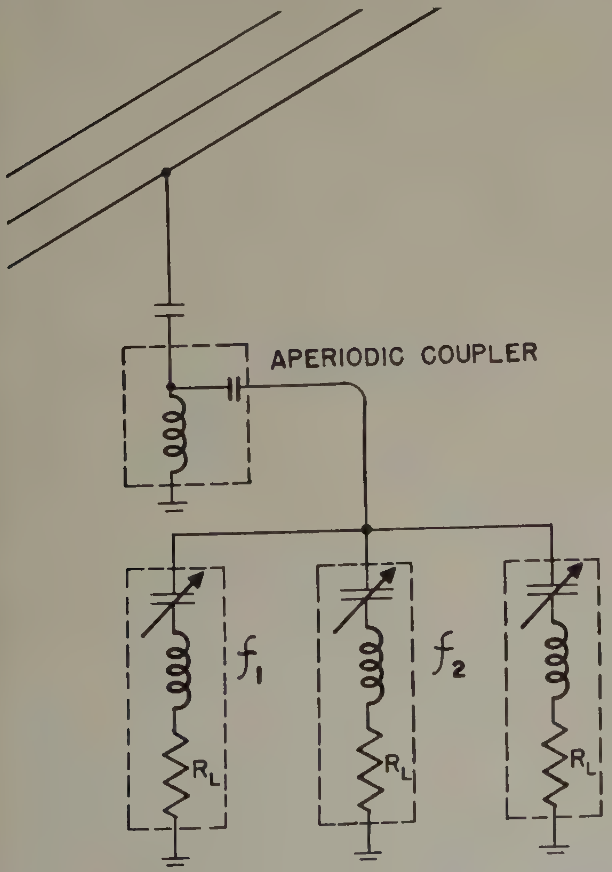


Figure 11. Typical 3-frequency arrangement for use with the aperiodic coupler

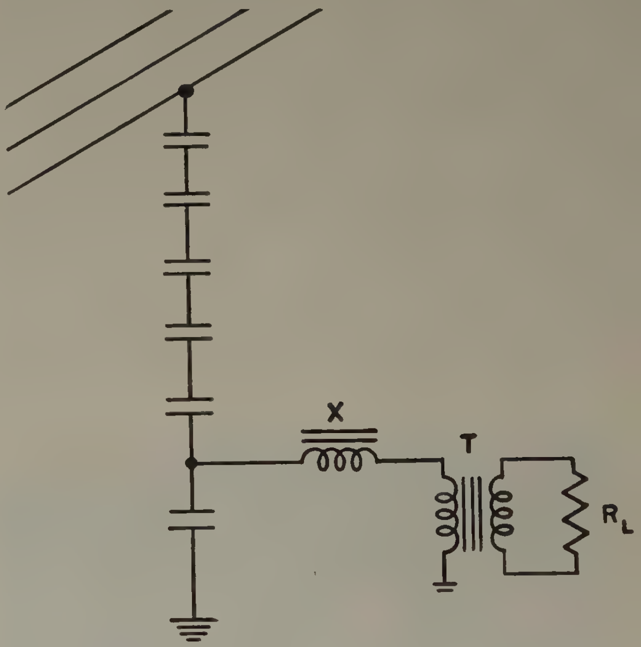


Figure 13. Basic potential device circuit

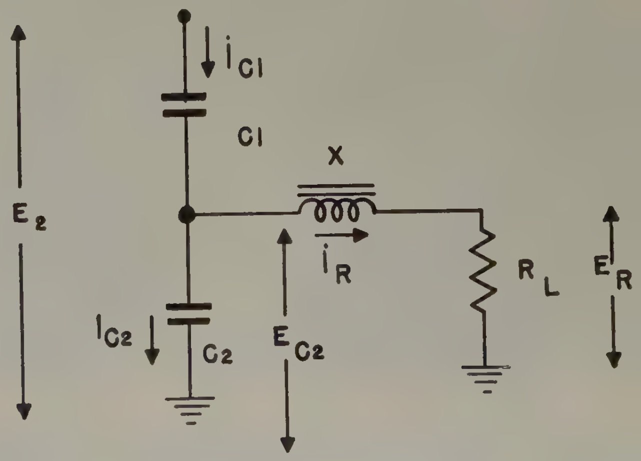


Figure 14. Equivalent circuit for potential device calculations

favor some particular frequency near the low end of the band.

If a number of transmitters are used with a single aperiodic coupler, it is customary to connect each to the common coupling unit through a single series resonant circuit. This terminates each transmitter to the line only at its operating frequency. The matching circuit is usually a part of the output circuit of the transmitter. The conventional arrangement for three transmitters is shown in Figure 11.

Next, let us examine the transfer characteristic from a single transmitter to the line. Figure 12 shows the result from the point of view of a 160-kc channel with the two other channels tuned to 67 and 50 kc. These are the same frequencies used in the example shown in Figure 4. Again Foster's Reactance Theorem applies, and the plot shows a marked decrease in the number of nodes and poles present in each path. This is one of the most important characteristics of the aperiodic coupler.

CAPACITOR POTENTIAL DEVICE

SHORTLY AFTER the aperiodic coupler was designed, the need for an associated potential device became apparent.

Coupling capacitor potential devices are well known to the industry. Certain changes in the conventional construction, however, can be made with resulting economy. Because the coupling capacitor is made of a number of capacitor sections stacked in series, it is quite simple to tap this stack at some desired point. The tap is obtained for a low cost, and high tap voltage is easily achieved. The high tap voltage is advantageous since it permits the potential device to deliver higher power for a given regulation.

The basic circuit diagram of the capacitor potential device is shown in Figure 13. A simplified circuit, used for computation, is shown in Figure 14. In this circuit the potential transformer leakage reactance is assumed to be lumped with the series reactor. A vector diagram showing the significant voltages and currents in the circuit is shown in Figure 15.

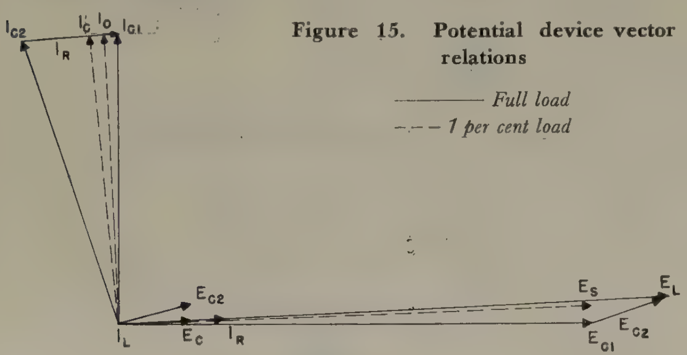


Figure 15. Potential device vector relations

——— *Full load*
– – – *1 per cent load*

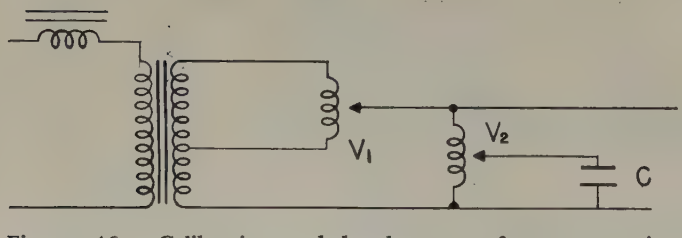


Figure 16. Calibration and burden-power-factor correction circuit

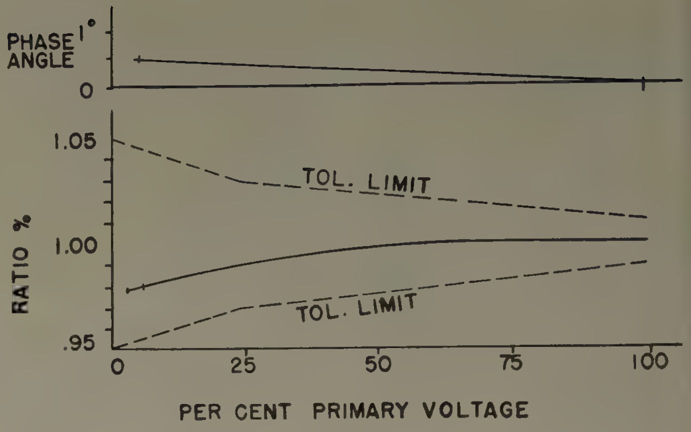


Figure 17. Voltage regulation

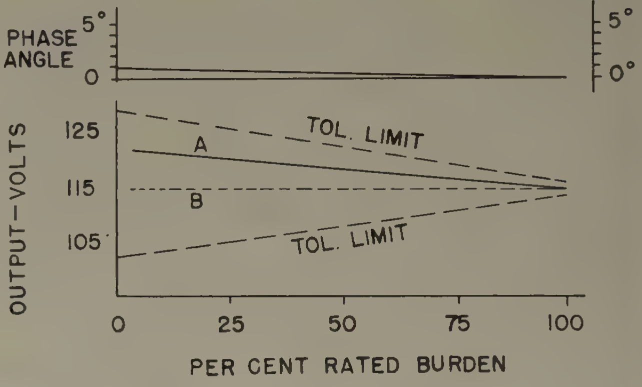


Figure 18. Burden regulation

A—Corrected at 100 per cent burden only
B—Corrected for any value of burden

The line voltage E_L is impressed across the entire unit. The current drawn by the network I_c leads this voltage by slightly less than 90 degrees. This current divides into two components, I_{c2} and I_R. I_R flows through the inductive reactance X and through the load resistor R_L'. R_L' is the equivalent of the load resistor and transformer copper losses, when referred to the high side of the transformer.

The voltage appearing across the load resistor is corrected in phase by the inductive reactance X until it is exactly in phase with the high voltage appearing at the input to the unit. Using this method, proper correction is achieved for all load values.

In metering equipment, it is desirable to provide a convenient means for calibration. The calibration means should be continuously adjustable, if possible, to provide maximum accuracy. In this potential device the ideal is closely attained through the use of a specially designed variac, V_1. The principal need for a calibration adjustment in this unit is to compensate for production variations in the values of C_1 and C_2. Figure 16 shows the manner in which variacs are used for calibration adjustment and also for power-factor burden correction.

Voltmeters, relays, watt-hour-meter elements, and synchroscopes all present an inductive load to the potential device. Both the power required for the composite burden and its power factor can be readily determined by usual methods and can be corrected to unity through the addition of the proper static capacitor in parallel with the burden.

Through the use of a variac, an adjustable voltage may be impressed across a 32-microfarad capacitor. Since the output voltage is nominally 115 volts, the dial scale on this variac, V_2, can be marked directly in vars from zero to over 150. Thus, when the lagging vars in the burden are determined, the proper compensation can be made by simply setting the dial on variac V_2 to the measured value in vars.

A portion of AIEE Standard Number *31* covers the performance of capacitance potential devices. The design parameters chosen for the potential device described in this article have resulted in a unit whose performance substantially exceeds the minimum requirements set forth in this Standard.

Two principal performance curves are shown. Figure 17 shows the step-down ratio error plotted versus applied voltage. The dotted lines show the tolerance permitted by the Standard. The phase-angle error at 100 per cent burden is within ±0.1 degrees. At 5 per cent primary voltage, the error is approximately one-half a degree.

Figure 18 shows the step-down ratio error plotted versus the magnitude of the burden at rated line voltage. Again, the dotted lines show the tolerance permitted by Standard Number *31*.

One additional feature results from the use of variac V_1 for calibration adjustment. This variac also may be used to compensate for the small error due to variations in burden magnitude. The potential device thereby can provide an exact ratio at all values of burden.

In final testing of these potential devices, the standard maximum burden of 150 watts is applied and the calibration variac set to provide the standard output voltage of 115 volts. A dial is next put on the unit and adjusted so that its scale, which contains a special calibration in terms of burden, is set to 150 watts. For other burdens, the dial is simply rotated to the scale reading corresponding to the new value of burden. The resulting performance curve also is shown on Figure 18 as a dashed line.

Both variacs are operated at less than half the normal rated voltage of similar units, and the windings are covered with a silicone grease to prevent any change in contact resistance. Tests have been continuously in progress for over a year without contact or winding oxidation becoming apparent.

Field tests soon brought out the fact that it was possible to space transmitter frequencies much closer than was practical when using the older tuning system. In addition, the usual narrowing of the passband at the low end of the spectrum was not experienced.

Tuning up a unit is a very simple procedure, as there is only one inductance to adjust.

Field experience with aperiodic couplers of all voltages has verified that the design aims have been entirely accomplished.

Model Tests of Turbine for Reclamation Project Are Completed

Model tests of a reversible pump turbine being built by Allis-Chalmers Manufacturing Company for the United States Bureau of Reclamation's Flatiron power and pumping plant on the Colorado–Big Thompson project near Loveland, Colo., have been completed.

The reversible pump turbine will be used primarily for irrigation and will pump water from the tail race of the Flatiron power plant into the project's Carter Lake reservoir. During periods when the pump turbine is not used for irrigation, it will operate as a turbine and supply peaking power to the electric system in northern Colorado, Wyoming, and western Nebraska.

The reversible pump turbine is rated to pump 370 cubic feet of water per second at 240-foot dynamic head, and will be used over a range of head from 170 to 300 feet. When operated as a turbine, it will generate about 12,000 horsepower at 290-foot head and will operate over a range of head from 290 down to 140 feet.

The unit is unique in that it will operate at 300 rpm when pumping and 257 rpm when generating power and will have a motor to drive the pump which will serve also as a synchronous generator. It is scheduled to be placed in operation in 1953.

Ireal A. Winter (center), chief of the Hydraulic Machinery Branch of the United States Bureau of Reclamation, Frank E. Jaski (left) and W. W. Weltmer, Allis-Chalmers engineers, view the model test reversible turbine and butterfly valve

Transmission-Line Capacitance and Voltage Gradient

H. B. DWIGHT
FELLOW AIEE

F. E. SCHEIDLER

THE AVERAGE VALUES of the capacitance and surface voltage gradient of a 3-phase transmission line can be computed quickly by well-known formulas. However, the surface voltage gradient on some parts of the line may be several per cent higher than the average value. Precise computations of this important quantity for the individual conductors are of engineering value and often are made.

The configuration of flat spacing, that is, with the three phases in a plane, is used in many important cases. A group of formulas is presented in this article for calculating the characteristics of the individual conductors for this type of transmission line. They save a considerable amount of work, compared with the solution by simultaneous equations which otherwise would need to be used.

The formulas are as follows, the notation for the dimensions being shown in Figure 1. The charge on a conductor is q coulombs per centimeter.

Flat spacing, ungrounded neutral, images not included.

$$q_b=\frac{V_b}{K\left(\log\frac{s}{r}-\frac{1}{3}\log 2\right)} \tag{1}$$

where V_b is the line-to-neutral voltage of phase b, $K=17.97\times10^{11}\times2.303$, and log denotes logarithm to base 10. For equation 1, see equation 121.[1]

$$q_a=\frac{V_a\left(\log\frac{s}{r}+\frac{j}{\sqrt{3}}\log 2\right)}{K\left(\log\frac{s}{r}-\frac{1}{3}\log 2\right)\left(\log\frac{s}{r}+\log 2\right)} \tag{2}$$

For q_c, use equation 2 changing V_a to V_c and $+j$ to $-j$.

Flat spacing, ungrounded neutral, images included.

$$q_b=\frac{V_b}{K\left(\log\frac{s}{r}-\frac{1}{3}\log 2-\log\frac{D_2}{D_1}+\frac{1}{3}\log\frac{D_3}{D_2}\right)} \tag{3}$$

$$q_a=\frac{V_a\left(\log\frac{s}{r}-\log\frac{D_2}{D_1}+\frac{j}{\sqrt{3}}\log\frac{2D_2}{D_3}\right)}{K\left(\log\frac{s}{r}+\log\frac{2D_1}{D_3}\right)\left(\log\frac{s}{r}-\log\frac{D_2}{D_1}-\frac{1}{3}\log\frac{2D_2}{D_3}\right)} \tag{4}$$

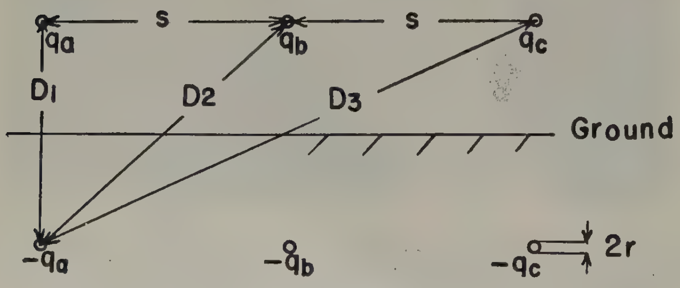


Figure 1. Flat-spacing transmission line, images included

For q_c, use equation 4 changing V_a to V_c and $+j$ to $-j$.

Flat spacing, grounded neutral.

$$q_b=\frac{V_b\left(\log\frac{D_1}{r}+\log\frac{D_2}{s}+\log\frac{D_3}{2s}\right)}{K\left[\left(\log\frac{D_1}{r}+\log\frac{D_3}{2s}\right)\left(\log\frac{D_1}{r}\right)-2\left(\log\frac{D_2}{s}\right)^2\right]} \tag{5}$$

For q_a and q_c solve three simultaneous equations, using numerical coefficients.

Charge density at angle Θ, going around the circumference of a conductor whose charge is q_1 per centimeter.

$$q_\theta=\frac{q_1}{2\pi r}-\frac{q_2}{\pi r}\left(\frac{r}{p}\cos\theta+\frac{r^2}{p^2}\cos 2\theta+\ldots+\frac{r^n}{p^n}\cos n\theta+\ldots\right)$$
$$\text{coulombs per square centimeter} \tag{6}$$

where q_2 is the charge per centimeter on a parallel conductor at distance p. The angle Θ is measured from the line joining the centers of the conductors.

The surface gradient due to q_θ is $4\pi q_\theta$ in absolute units. In practical units, the gradient at the surface of an isolated conductor is

$$17.97\times10^{11}q/r \text{ volts/centimeter} \tag{7}$$

where r is the radius in centimeters.

Voltage gradient at the surface of the middle conductor, with flat spacing, one conductor per phase, ungrounded neutral, is

$$\frac{V_b}{2.303r\left(\log\frac{s}{r}-\frac{1}{3}\log 2\right)} \text{ volts/inch} \tag{8}$$

where dimensions are in inches.

Maximum voltage gradient at the surface of a middle conductor, with flat spacing, two conductors per phase, ungrounded neutral, is

$$\text{Maximum gradient}=\frac{V_b\left(1+\frac{2r}{p}+\frac{2r^2}{p^2}+\ldots\right)}{2\times2.303r\left(\log\frac{s}{\sqrt{pr}}-\frac{1}{3}\log 2\right)} \text{ volts/inch} \tag{9}$$

where dimensions are in inches.

A similar equation can be written down for the middle phase when the neutral is grounded. The gradient then will be approximately 2 per cent less than it was in the case of equation 9.

REFERENCE

1. Electric Power Transmission (book), L. F. Woodruff. John Wiley and Sons, Inc., New York, N. Y., 1938, page 77.

Digest of paper 52-128, "Capacitance and Surface Voltage Gradient of Transmission Lines," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE North Eastern District Meeting, Binghamton, N. Y., April 30–May 2, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Polyethylene Terephthalate as a Capacitor Dielectric

M. C. WOOLEY G. T. KOHMAN WILLIAM McMAHON

Polyethylene terephthalate, or "Mylar," is a new rival of paper for use as the dielectric in electric capacitors. It appears superior in regard to insulation resistance, temperature coefficient of capacitance, and operating temperature range.

THE STEADY increase in the severity of operating conditions for capacitors and the need for more diverse characteristics have spurred the search for new and better capacitor dielectrics. The synthetic plastics industry, which is the source of a number of useful dielectric materials, has recently produced a new and promising dielectric in film form known as polyethylene terephthalate, or "Mylar." It is a colorless transparent material with a specific gravity of about 1.4. It is exceptionally tough, having a high tensile strength and much better tear resistance than most plastic films. For this reason, it is feasible to make very thin films which is a decided advantage for capacitor insulation. The softening point of the film is about 240 degrees centigrade. However, under proper conditions it can be fused at somewhat lower temperatures. Mylar film is quite stable chemically. It is highly resistant to moisture penetration and also to decomposition by hydrolysis. Some of the properties which suggest its use as a capacitor dielectric are shown in Table I. The dielectric breakdown strength of the film is found to be approximately 50 per cent greater than that of impregnated paper. At room temperature the d-c resistivity of Mylar is very high, its power factor is about the same as that of impregnated paper, and its dielectric constant is intermediate between paper and the hydrocarbon polymers, polystyrene or polyethylene.

Table I. Properties of Mylar Favorable for Use as a Capacitor Dielectric

Frequency, Kc	Dielectric Constant*	Power Factor*
1	3.4	0.0055
10	3.4	0.018
100	3.3	0.016

D-c resistivity* (400 volts) 3×10^{15} ohm-centimeters
Dielectric breakdown strength* (single layer of 1.33-mil film)—6.0 kv/mil
Conducting paths in 1.33-mil film—Nil

* At 25 degrees centigrade.

In addition, some of its electrical properties can be improved by suitable heat treatment. This is illustrated in Figure 1 which shows the effect of heat treatment at temperatures up to the softening point of the film. A temperature of approximately 200 degrees centigrade for 2 hours is sufficient to produce the greater part of the benefits of such a treatment, but the period of heating is not critical and longer times can be used to obtain some additional improvement. However, heating for a very much longer time or at much higher temperatures may produce a degradation, especially in breakdown voltage, as illustrated by the last point of the dielectric strength curve in Figure 1. Excessive heating leads to rapid crystallization of the film, and the reduction in breakdown voltage of the units is believed to be due to the resulting embrittlement and mechanical damage to the film although there may be a change in its inherent dielectric strength. The film used in these tests was highly oriented originally, and it is known that heat treatment causes deorientation. This may indicate that the dielectric properties of highly oriented film are inferior to those of film having a low degree of orientation. However, it is probable that changes in other properties, such as crystallinity, also take

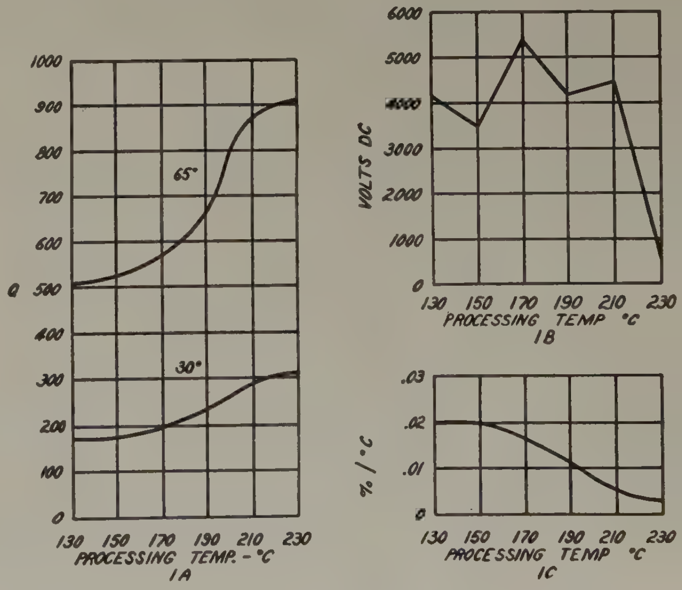

Figure 1. The effects of capacitor unit processing temperature under varying conditions

1A—Q at 1,000 cycles
1B—Ultimate dielectric strength
1C—Temperature coefficient of capacitance in per cent per degree centigrade

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Revised text of conference paper recommended by the AIEE Subcommittee on Dielectrics of the Basic Sciences Committee and approved by the AIEE Technical Program Committee for presentaton at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952.

M. C. Wooley, G. T. Kohman, and William McMahon are with the Bell Telephone Laboratories, Inc., Murray Hill, N. J.

place on heating, and these also may affect the electrical characteristics of the film.

The data in Figure 1 were obtained with 0.2-microfarad capacitors having a single layer of Mylar approximately 0.0009 inch thick between electrodes. From the breakdown voltage data it can be seen that an ultimate dielectric strength of 4,000 to 6,000 volts per mil is realized. Tests with thinner single sheets between electrodes have given results averaging as low as 2,000 volts per mil, but it should be emphasized here that these are average results on a number of capacitors each having a total dielectric area of the order of 2 square feet.

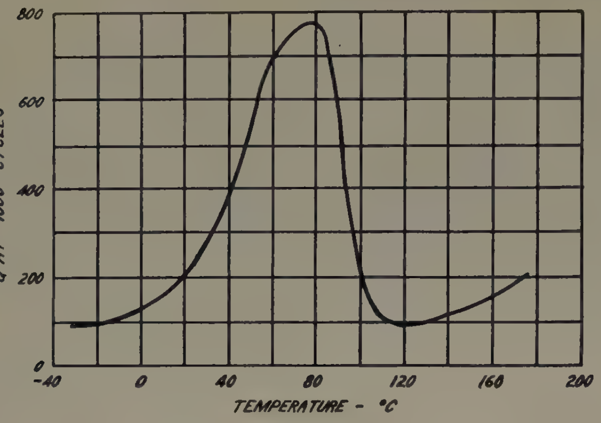

Figure 2. The effect of temperature on Q at 1,000 cycles of a Mylar capacitor

Capacitor units which have been heat treated at temperatures of approximately 200 degrees centigrade have the layers of film fused together, and to a considerable degree the film adheres to the foil so that the winding becomes a solid mass. Consequently, such units show a high degree of capacitance stability even when they have been subjected repeatedly to temperatures as high as 150 degrees centigrade.

The Q of Mylar at 1,000 cycles exhibits a maximum at about 80 degrees centigrade as illustrated in Figure 2. At lower frequencies the peak is reduced and tends to shift slightly toward lower temperatures, while at much higher frequencies the curve is relatively flat. The variation in Q at 1,000 cycles with temperature makes direct comparison with other dielectrics difficult, but in general it may be said that the Q of Mylar is at least equivalent to that of mineral-oil-impregnated paper over the temperature range of −40 to +100 degrees centigrade. It is inferior at room temperature and below to some impregnated paper capacitors which are designed especially to have low a-c losses. These and the other data reported herein are based on relatively few lots of the film and, therefore, are not necessarily representative of what may be expected in large scale use of the material. However, the data which have been reported herein agree relatively well with that published by Reddish.[1]

The capacitance-temperature characteristic of Mylar capacitors is shown in Figure 3. Large variations in capacitance are noted but mainly outside the usual range of temperatures. Within the operating range usually encountered, the temperature coefficient of capacitance with suitably processed units is lower than for any of the commonly used dielectric materials excepting mica. Frequency affects the shape of the capacitance-temperature curve, and at frequencies higher than the 1,000 cycles for which Figure 3 is plotted, the slope of the curve becomes somewhat greater over its central portion.

Another of the outstanding properties of Mylar is its high resistivity over a very wide temperature range. Of the commonly used capacitor dielectrics, only polystyrene exhibits a higher resistivity, and its use has been limited by a relatively low softening point, high cost of thin films, and other factors. Figure 4 is a typical leakage resistance curve. It shows for comparison the leakage resistance characteristic of a mineral-oil-impregnated paper capacitor. It may be noted that the Mylar capacitor has approximately 50 times the insulation resistance of the paper capacitor over the whole temperature range.

When operated with appreciable amounts of internal a-c corona, Mylar film capacitors fail within hours or days indicating only moderate corona resistance. Unimpregnated Mylar capacitors exhibit corona at 300 to 400 volts rms alternating current. Impregnation with oil or other suitable material is necessary if a-c potentials greater than these are involved. It is encouraging to note, however, that capacitors do not fail immediately on exposure to severe corona. Therefore, premature failure is not likely to result from infrequent short periods of overvoltage.

The stability of Mylar under high electrical stress and at high temperatures is likely to prove one of the most important of its advantages over other capacitor dielectrics. Impregnated paper capacitors are generally limited to operation at temperatures of 100 degrees centigrade or less, but preliminary tests indicate that Mylar film capacitors may be used at temperatures at least as high as 150 degrees centigrade. Life tests in which paper capacitors are operated at a stress of approximately 700 volts per mil at 85 degrees centigrade are usually expected to produce

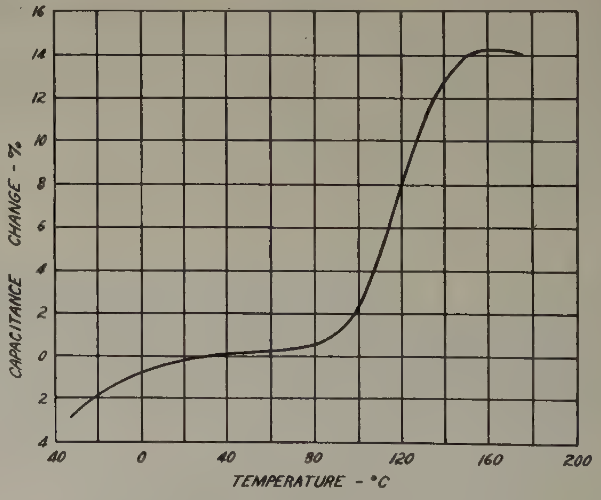

Figure 3. The capacitance-temperature characteristic of a Mylar capacitor at 1,000 cycles

capacitor failures within a period of 1,000 hours or less. In a test with Mylar capacitors at a dielectric stress of approximately 600 volts per mil there have been no failures after 5,000 hours at 130 degrees centigrade, plus more than 4,000 hours at 150 degrees centigrade. Much more study will be required before temperature and voltage ratings can be firmly established, but these preliminary results are most promising. This is particularly so in the light of experience with other organic dielectric materials.

All of the results discussed herein have been obtained with conventionally wound capacitors containing one or two layers of film between aluminum foils and heat treated after being wound. The use of an impregnant may be necessary under conditions such as previously noted for high alternating voltages, but in general it is felt that impregnation is unnecessary or even undesirable especially for those applications where the ultimate in insulation resistance or minimum a-c losses is required. On the other hand, where the highest electrical characteristics are not required but where cost is a primary consideration, Mylar also appears to fill the need. Mylar capacitors are much more inert to the harmful effects of atmospheric moisture than impregnated paper types. Therefore, for applications involving conditions of moderate humidity, we believe that it is possible to use heat-treated Mylar units without additional protection. An experimental capacitor intended for such application is shown in Figure 5. The terminals of this capacitor are headed wires embedded in the ends of the unit during heat treatment so that they are securely anchored. Heat-treated units of Mylar have withstood continuous exposure to atmospheric conditions of 90 per cent relative humidity at 85 degrees Fahrenheit for 7 months with no significant change in insulation resistance. Life tests on continuous voltage of these unencased Mylar capacitors also indicate that so long as humidity and temperature conditions are not extreme the life is not significantly affected by exposure to atmospheric conditions.

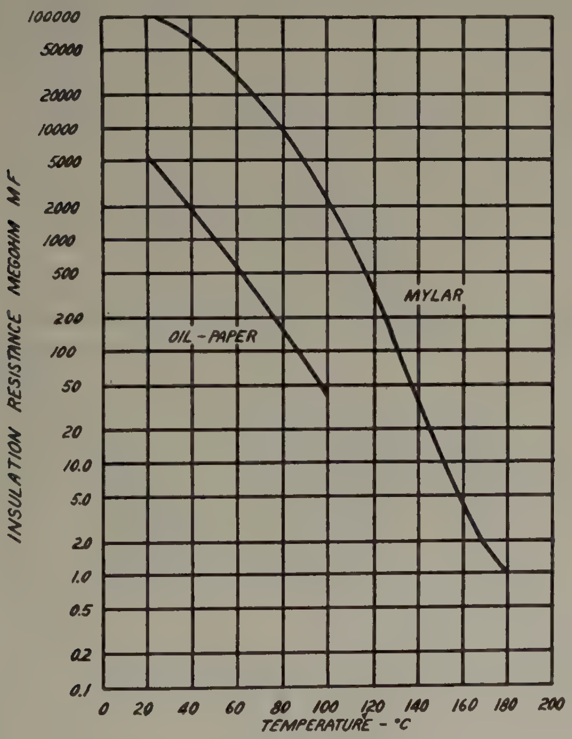

Figure 4. Typical leakage resistance curve. Note that the insulation resistance of a Mylar capacitor is approximately 50 times that of a good mineral-oil-impregnated paper capacitor

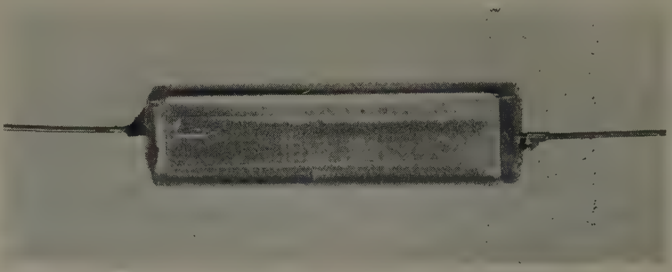

Figure 5. An experimental Mylar capacitor intended to be mounted by its leads

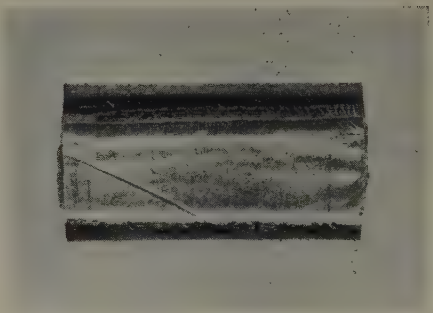

Figure 6. A metallized Mylar capacitor unit

The high mechanical strength and tear resistance as well as the high softening temperature of Mylar film make it particularly adaptable to current metallizing techniques wherein the metallic film is deposited on the dielectric by condensation of the metal vapor under vacuum.[2,3] Metallized Mylar capacitors, such as illustrated in Figure 6, have all the advantages of metallized paper types including small size and self-healing characteristics. In addition, they have the further advantage over paper in that the Mylar film does not need to be lacquered before it is metallized. Results with metallized Mylar are as yet rather scattered, but there is reason to expect that capacitors made with metallized Mylar will be smaller than those with equivalent performance utilizing metallized paper.

In conclusion, it appears that Mylar film may become the chief contender for the place of paper as the dielectric in electric capacitors. Further, the Mylar capacitors will be superior in several respects, including insulation resistance, temperature coefficient of capacitance, and operating temperature range.

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Loom Desynchronizing

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When rows of looms on the upper floor of a building are operating in a certain unison, their combined in-step forces tend to cause structural damage to the walls and building foundation. A scheme is presented to prevent adjacent looms from getting in this dangerous synchronism.

PEOPLE WHO have been in a weave room have felt the building sway so much that they have wondered why the building does not collapse. This fact has worried mill owners and huge fortunes have been spent to strengthen and re-enforce buildings so that they will withstand these forces safely. Just as an army marching in step across a bridge can cause the bridge to collapse, so can a number of looms, operating exactly in step, cause great damage to the building housing these looms. The bridge can be saved by having the soldiers break step as they march across it. Similarly, the building housing the looms can be saved if the forces moving in a given direction at any given moment can be kept to a minimum by desynchronizing them.

This problem is of no great concern in a mill where the looms are located on the ground floor. There are, however, a great many of the older mills where looms must be placed on the second, third, or fourth floors. It is in these mills that a solution to the problem must be found. Strengthening the walls and foundations is possible but extremely expensive. As is true in all cases of the trouble, the best solution is to eliminate the source of the trouble. The trouble here is definitely due to a great many looms being exactly in step as far as their lay positions are concerned. The lay of a loom has considerable mass and it is started and stopped at tremendous rates of speed change. When large numbers of lays are started in the same direction at the same instant, huge resultant forces are exerted on the building. At the next instant, when all the lays are stopped, the same force is exerted in the opposite direction.

The swaying motion of a weave room is never constant; it operates in cycles. At one instant it is practically unnoticeable and within a short time it reaches a maximum when it seems as though the building must fall. By looking lengthwise along a row of looms so that lays of all the looms are in view, it can be seen that a group of looms, all the same type, all weaving the same goods, and with the same motor drive, never operate at exactly the same speed. While watching these looms, there are times when practically all the lays are in step and a short time later are all entirely out of step. The cycles of severe vibration of the building definitely coincide with the time when a large number of looms have their lays in synchronism.

The vibration caused by a loom could be entirely eliminated by the proper counterweighting of all the reciprocating parts and especially the lay. This is impossible because the extra inertia, that would have to be added to the loom would cause certain destruction of the loom at times of protection stop. Another way of eliminating the resultant force to the building is to operate looms in pairs and have them operate at exactly the same speed and with a relationship to each other so that the lays of the two looms always will be traveling in opposite directions. When two such looms are placed back to back it becomes obvious that they will operate as a single counterbalanced unit as far as the resultant forces to the building are concerned. If a whole weave room is considered to be made up of pairs of looms, each pair being a counterbalance unit, it becomes apparent that no thought need be given as to the lay position relationship of the several 2-unit groups. Since each of the 2-unit groups is counterbalanced, it makes no difference what the exact lay-position relationship of the various 2-unit groups may be; the total resultant force on the building due to lay motion always will add up to zero.

OPERATING LOOMS IN PAIRS

THE IDEA OF operating looms in pairs has been considered many times. There were always two main difficulties: 1. the cost of either a mechanical or an electrical scheme to tie looms into pairs was too great, and 2. it was impossible to weave perfect cloth with any device tried. There recently has been developed, however, an electrical scheme whereby two looms will operate indefinitely at a fixed predetermined crankshaft-position relationship, one to the other. The scheme has the advantages of being simple, low in first cost, and in no way affects the quality of cloth being woven.

Figure 1 shows the basic principles involved in the solution of this problem. Looms *1* and *2* are located physically front to front. Here the lays are moving in the same direction at all times with respect to the building. The forces of starting and stopping the lays are added together in regard to their reaction to the building. Looms *3* and *4* show the relative position of crankshafts of two front-to-front looms where the lays of the two looms are always started and stopped together, but their motion is always in opposite directions. The forces of these two lays are now always opposing each other and the net force on the building is zero. If a scheme can be devised which

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will bring two looms into the position of looms *3* and *4* of Figure 1 and keep them in these relative positions, these two looms will never produce a resultant force on the building. If then all of the looms are operated in like pairs, there still will be no resultant force on the building.

It is practically impossible to find two looms which will continue to operate in exact synchronous relations on their own accord. Either one or the other of the two always will go a little faster than the other. This is due to several conditions that cannot be controlled:

1. Due to manufacturing inequalities of the motors there may be several revolutions difference in speed at the same load conditions.
2. There is usually a slight difference in actual load on a loom. This may be due to many reasons, such as bearing friction, shuttle check adjustments, pick adjustments, and many others.
3. There is always a slight creep in the clutch and since no two clutches can be adjusted exactly the same, there always will be a difference in the clutch creep between any two looms.

Any scheme to keep two looms 180 degrees out of phase must be able first to detect that one loom is creeping ahead of the other, and then, to take some corrective action to keep the two looms at exactly the same speed. In designing such a scheme or device, the basic operation of the loom must not be affected and the following conditions must be met:

1. Either of the two looms must be able to be started and stopped at any time without affecting operation of the other.
2. The speed of the loom must not be reduced at the instant of picking or beat-up, since this might cause faulty picking or a mark in the cloth. This latter is especially true of synthetic yarns.

The schematic diagram of Figure 2 shows a scheme which will meet all the requirements of keeping a pair of looms operating with the lays approximately 180 degrees out of phase at all times.

The following apparatus is involved:

1. A magnetic control switch for each loom replaces the present manual switch.
2. A maintained contact "start-stop" master switch for each loom. This switch may be mounted directly on the loom.
3. A 12-volt rated switch for each loom, operated by the loom shipper-rod. This switch is closed when the loom is in operation.
4. A 25-volt-ampere warp-stop transformer for a pair of looms. If the present looms have warp-stop transformers, one of these may be used.
5. One single-pole normally closed-contact 12-volt coil relay for each loom. These relays must have a 600-volt rating for their contact since they handle the coils of their respective loom switches at line voltage.
6. One crankshaft-operated switch for each loom which must be the equivalent of a single-pole double-throw switch with a neutral or off position.

OPERATION

Assume the zero degree position of the crankshaft of the loom as exact front center position. The crankshaft-operated switches of each loom are then set to operate as shown hereafter. This is for front-to-front looms; back-to-front positions would require one loom to have its crankshaft switch set 180 degrees away from the position indicated.

A to *B* closed from 330 degrees to 355 degrees.

A to *C* closed from 5 degrees to 30 degrees.

Both circuits open from 355 degrees to 5 degrees and from 30 degrees to 330 degrees.

By studying the schematic diagram in Figure 2, it will be seen that the only time a control relay can be picked up is when one loom is in the position of 5 degrees to 30 degrees while the other is in the position of 330 degrees to 355 degrees. Assume now that both looms are operating and loom *1* is 10 degrees past front center when loom *2* reaches 330 degrees. This will pick up relay *CR-1* which in turn drops out contactor *M-1* and the loom *1* motor is disconnected from the line. It will remain disconnected until the 30-degree position is reached when *CR-1* drops out and *M-1* picks up. This insures full speed and power at the time of pick and beat-up. It will be noted that the loom that is behind never will have its motor disconnected at any time.

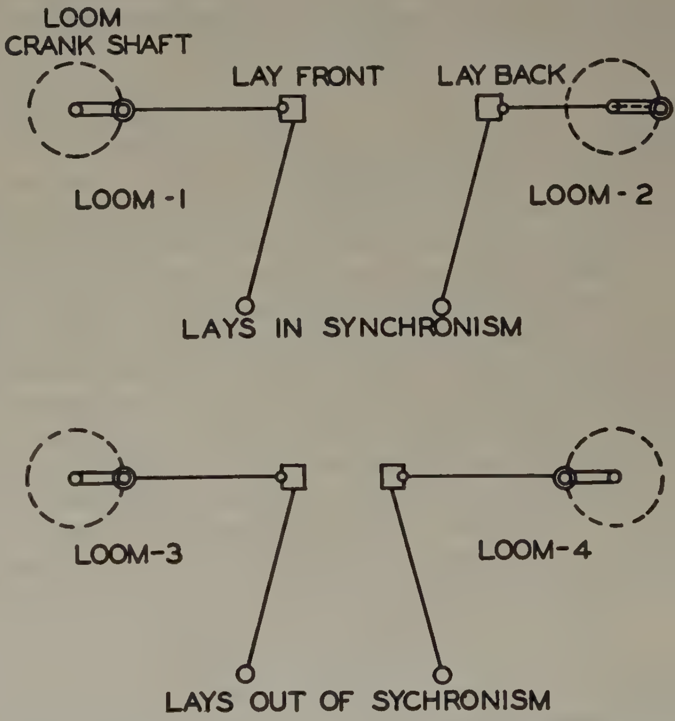

Figure 1. When the lays of looms are in synchronism, their forces are additive, and when the lays are operating in opposition, their forces are cancelled

When one loom only is to be operated, the motor for that one must be operating and the other may or may not be operating. When loom *1* shipper is put into the on position, loom *1* will operate. Since loom *2* is not operating now, its shipper-operated limit switch will be open and, therefore, neither relays *CR-1* or *CR-2* ever can pick up. Loom *1* therefore will operate under full power at all times.

As soon as the second loom is started, both shipper. switches are closed and relays *CR-1* and *CR-2* are now controlled by the crankshaft limit switches. However, unless the looms are within 30 degrees each of being exactly in the crankshaft relationship desired, nothing can happen. The looms will operate under full power and as one gradually gains on the other, they ultimately will reach a point where they are within 30 degrees of being exactly opposite. At this point the loom that is ahead will be slowed down a few degrees of travel at the start of the crankshaft acceleration for as many cycles as necessary to bring them exactly opposite. The looms then both will be under full power during the complete cycle as they continue to operate in the 10-degree dead zone. As soon as the faster loom goes more than 10 degrees ahead, its relay again will click once or twice to disconnect the motor momentarily at the beginning of the lay acceleration.

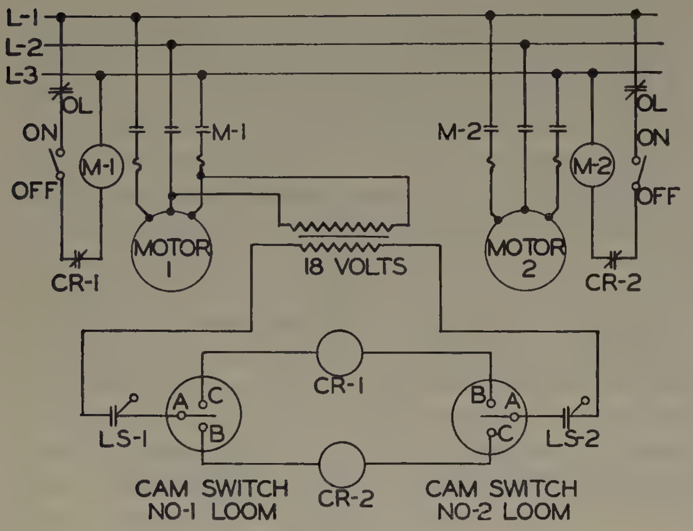

Figure 2. Schematic diagram of connections to two looms of control relays and cam switches for the desynchronizing of the looms' lays

ADVANTAGES

This scheme of operation has a number of advantages which becomes apparent as the system is studied. Some of these are listed herewith:

1. By choosing to disconnect the motors for a few degrees of crankshaft motion only and then immediately putting full power on the motor the loom will be at full speed at the time ofpick and beat-up. This insures that the operation of the loom and the quality of cloth will not be impaired.
2. By opening the motor contactors at the front-center or back-center point, it is assured that the power taken by the motor is close to zero and, therefore, there will be a minimum of contact burning or pitting due to frequent operation. This assures long contact life.
3. By opening the motor circuit at the same point each time and that just at the instant when the lay is to be accelerated, a constant and fixed amount of forward motion is lost every time the motor contact is opened.
4. By observing the frequency of operation of the correcting effect, the loom fixer has a definite gauge as to the correctness of the clutch adjustments. The correcting effect will take place when the fast loom has gained more than the 10 degrees of dead zone. A single or two correction cycles should correct close to the 10 degrees of dead zone. The looms then should run without correction for 40 to 60 picks. If the frequency becomes much greater, it is an indication that the loom that is not correcting has too much clutch slippage and that the loom fixer should adjust it.
5. The scheme allows the operation of either of the pair of looms as a single unit.
6. Either of the looms may be started or stopped without affecting the operation of the other loom.

Several trial installations of the foregoing scheme have been made and performance regarding loom operation has been excellent. Up until recently, the lack of a suitable device to be used as a crankshaft-operated switch has been a deterrent in making many installations. Various switches have been used but their life has been comparatively short.

ANOTHER SCHEME

Another scheme for loom desynchronizing has been developed and applied to a number of looms by G. A. Winterburn of Putnam, Conn. The scheme employed by Mr. Winterburn requires that one of the pair of looms be definitely slower than the other. To the faster one then is applied a relay and timing device which will reduce the speed of this second loom slightly by inserting resistance into the motor leads for a number of complete picks. A similar crankshaft switch is required for this scheme to act as intelligence for the start of the timed period that resistance is inserted into the motor leads. On many kinds of cloth this is completely satisfactory. The Putnam Mills Corporation has 150 Draper XD looms equipped with this device and has had complete satisfaction since early 1950. In this particular installation it has been found that the building movement was reduced to 15 per cent of the value before the installation and a very expensive building reinforcement has been avoided.

Of particular interest is the fact that Mr. Winterburn has developed a crankshaft switch using the automobile distributor principle and this apparently has proved completely satisfactory. The life of the relay and magnetic switch parts promises to be very long. With properly adjusted looms, there should be not more than four or five operations per minute on the faster loom and, of course, no operation on the slower loom. On the basis of a 16-hour day, the average switch life should be well over 5 years.

Circuit Breakers in the Bonneville Power System

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USE OF THE FACILITIES of the Bonneville Power Administration (BPA) network for tests of the Brown Boveri 230-kv air-blast circuit breaker at the switchyard of Grand Coulee powerhouse of the Bureau of Reclamation was motivated by the desire of all concerned to check the operating characteristics of a high-voltage, high-interrupting-capacity air-blast-type circuit breaker which has the following important advantages as compared with the conventional dead-tank-type oil circuit breaker: 1. absence of fire-hazardous oil; 2. decrease in oil storage facilities; and 3. ease of inspection of contacts and of maintenance and less frequent maintenance.

The BPA always has considered circuit breakers of primary importance in the operation of the system, and since the early days of its operation has made use of the system for testing circuit breakers of different types and different manufacture, including some of foreign make of the air-blast and oil-poor types. To promote a competitive situation on the domestic market, the BPA provided facilities for the smaller American manufacturers who did not have their own high-power testing facilities and as a result have been able to obtain appropriate circuit breakers at a lowered cost.

There is no way of reliable extrapolation of the ability of the circuit breaker to interrupt currents of much larger magnitude or at much higher voltage even if there are sufficient data on the operation of smaller circuit breakers of the same type within their rating. When, following the American development of high interrupting capacity high-voltage circuit breakers tested at Grand Coulee, a new type 6,000,000-kva (symmetrical rating) 230-kv circuit breaker was developed by the Brown Boveri Company of Switzerland, they were anxious to test it in a system under actual operating conditions. As there was only one place in the world where sufficient concentration of power at the 230-kv level was available, the Grand Coulee power plant, they entered into an agreement with the BPA and the Bureau of Reclamation to test this new circuit breaker at the switchyard of Grand Coulee, interconnected through the BPA network with several other utilities in five Pacific Northwest states and British Columbia. Such tests always have been made in the presence of engineering representatives of the American operating and manufacturing companies and it is hoped that this procedure not only will permit the BPA to select better circuit breakers but will contribute to the development by American manufacturers of circuit breakers either entirely free of oil or containing it in a minimum amount.

The Brown Boveri circuit breaker, following usual practice, was tested not only for interrupting capacity of fault currents but also for ability to interrupt comparatively small line-charging current without restrikes. In both instances the circuit breaker showed a very good performance; the contacts could be inspected speedily and very little wear and tear of contacts was observable even after a series of heavy fault-current interruptions up to 10,500 megavolt-amperes asymmetrical.

As previously indicated a reduction in circuit-breaker costs as well as an improvement in circuit-breaker characteristics have been realized at least partially because of the availability to manufacturers of a power system capable of providing heavy fault currents. For example, in 1939 the largest 230-kv circuit breakers that it was possible to purchase were rated 2,500,000 kva 3-cycle opening time, and had no high-speed reclosing at a cost of approximately $70,000. In 1950 it was possible to obtain a circuit breaker having an interrupting rating of 7,500,000 kva, 3-cycle opening time, and a 20-cycle reclosing time at a cost less than $50,000. At the present time it is possible to obtain 10,000,000-kva circuit breakers for about $70,000 regardless of the fact that material and labor costs have doubled during the last 12 years.

The series of circuit-breaker tests conducted on the Bonneville system during the past 12 years, a careful analysis of oscillograms taken during these tests, and the inspection of circuit breakers after the tests has resulted in a better understanding of test methods and evaluation of circuit-breaker performance. Because of this, we believe that the accepted American methods of circuit-breaker tests and the method of checking circuit-breaker rating could be improved considerably. For example, during some of these tests it was obvious that under certain conditions strenuous operation of the circuit breaker was evident at less than rated interrupted duty (as calculated according to the American Standards Association method) and under other conditions less strenuous operation occurred at higher than rated interrupting duty. Analysis of this inconsistancy indicates that in interruption of asymmetrical current, the strain on the circuit breaker depends upon whether the current finally is interrupted in passage through zero after going through the major loop of an asymmetrical short-circuit current or through the minor loop—in other words upon the point of the current wave at which the contacts of the circuit breaker separate in relation to final interruption and therefore upon the amount of energy developed by arcing taking place during the current loop immediately preceding interruption. This important condition is not taken into consideration in interrupting duty rating as calculated according to the present American Standards Association method.

Digest of paper **52-30,** "High-Voltage Circuit Breakers in the Bonneville Power System," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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A Compact, Inexpensive A-C Network Analyzer

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SINCE THE INTRODUCTION of the first a-c network analyzer in 1929, the number in use has risen to more than 25 at present. Although existing types of a-c boards have proved invaluable, a great need exists for a much more compact and less expensive board. To meet this need an a-c board has been designed and built which occupies a floor space of about 60 square feet, compared with about 700 square feet for a board of conventional design, and which can be built to sell for about 20 per cent of the cost of a board of conventional design.

The great reduction in size and cost was made possible by four means: the use of uncalibrated impedance units,[1] which are set with the aid of instrument readings; the representation of impedances by their conjugates;[2] the use of a low power level; and the use of standard mass-produced radio-electronic parts.

The impedance units on the board consist of rheostats either in series or parallel with adjustable reactors. If impedance is to be set, constant current is supplied to the impedance unit from one of the generator units which is reconnected to act as a current source. The resistance and reactance then are read on the wattmeter-varmeter. For setting admittance, a similar procedure is used except that a constant voltage source is used instead of a constant current source. A switch is provided which disconnects the desired unit from the circuit it is in and connects it to the source of power for admittance or impedance setting.

One of the most difficult and important problems in the design of a conventional a-c board, the design of the adjustable inductive reactors, is overcome in this board by representing all impedances by their conjugates. Since inductive reactance then is represented by capacitive reactance, the inductors for the line units are replaced by capacitors which have an inherently high Q and are very linear. While it might seem that this advantage would be cancelled by the disadvantage of using inductors to represent shunt capacitance, this is not so for several reasons: the fewer shunt units needed compared to line and load units, the smaller effect of the shunt units on the system performance, the smaller variation of voltage across a shunt unit than of current through a line unit, and the fact that the losses in the inductor usually can be included in a load connected to the same bus.

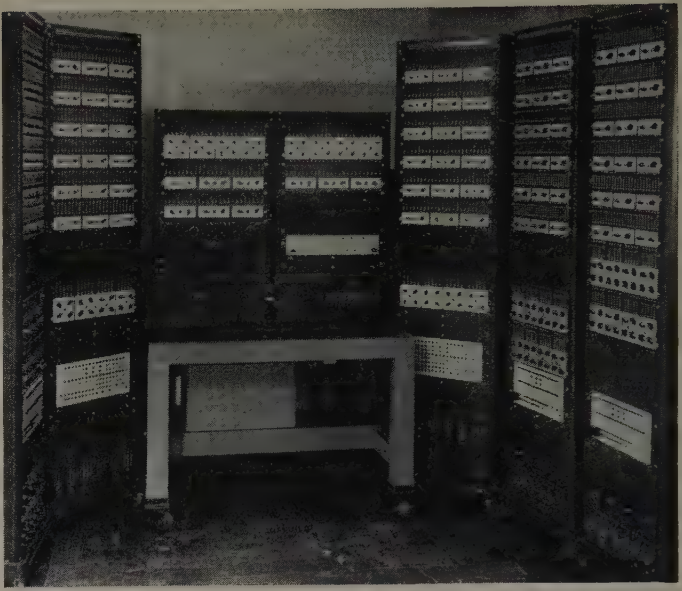

Figure 1. The network analyzer built at Northwestern University

The base power of the board is only 0.5 watt, lower than that of previous a-c boards. The use of a low base power reduces the required rating of the generators and makes the use of electronic generator units both feasible and attractive. Together with the use of a high base impedance, which is required in order to limit the size of the capacitance used, the low base power results in a low base current of 10 milliamperes. This permits the use of small, inexpensive resistors in the line and load units and the use of small switches, plugs, and jacks with freedom from troubles caused by high contact resistances.

The board will operate from any 60-cycle single-phase circuit and requires only 1,000 volt-amperes. The 12 generator units are driven by an electronic frequency doubler which doubles the line frequency to 120 cycles, the operating frequency of the board.

The central instrument system has three indicating instruments: a voltmeter, ammeter, and watt-varmeter. They are driven by two amplifiers, one for current and one for voltage. With them scalar values of voltage, current, and real or reactive power can be measured. When used with the instrument phase shifter, vector values of voltage and current in either polar or rectangular form also can be measured.

The low cost of a-c boards such as described should enable power companies, both in the United States and abroad, to own one. The increased number of studies thereby made possible should result in further increase in the economy and reliability of electric power supply.

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Digest of paper **52-113**, "A Compact, Inexpensive A-C Network Analyzer," recommended by the AIEE Committee on Computing Devices and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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The authors wish to acknowledge the contributions of E. R. Owen, formerly with Northwestern University, Evanston, Ill., and now with the General Electric Company, Schenectady, N. Y., who designed the instrument amplifiers used in the project.

The 3-Gun Shadow-Mask Color Kinescope

H. B. LAW

Although the development of color television is in a fluid state, one of the outstanding steps in the progress of the art is the tricolor kinescope. There have been many problems to overcome, not only in the functioning of the tube, but in its construction.

WHEN all-electronic television became a reality it was apparent that an ideal reproducer for color television should consist of a single kinescope capable of displaying the color picture directly. Considerable interest in the problem since then has resulted in quite a number of proposals for single-tube color kinescopes, and much time and effort has been expended in experimental work. No systematic review of the literature will be given nor will a description of the operating principles of the various kinds of proposed tubes be undertaken as a paper covering these subjects has been published recently.[1] Rather, it will be the purpose of this article to give an over-all description of the Radio Corporation of America (RCA) 3-gun shadow-mask color tube including its construction and operating characteristics.*

The shadow-mask tricolor kinescope employs additive color reproduction. Now it may be said that the basic requirements of any additive color reproducer are

1. A set of suitable primary lights.
2. A method for adding these primaries.
3. A method for controlling the amount of each primary to be added.

In regard to the first requirement, the primaries that are used in the shadow-mask tube have their origin in the excitation of three kinds of phosphor that are placed on a glass plate inside the tube envelope. These phosphors have been chosen as having the best combination of high efficiency and desirable chromaticity that is available at the present time. The gamut of colors that it is possible to produce with these primaries compares very favorably with that possible with the best processes of color reproduction and is much superior to most commercial processes.

Turning now to the method of adding primaries, the system of juxtaposition is used in the tricolor tube. Small phosphor dots of three kinds are placed close together on a glass plate and three electron guns are located in such a position that all phosphor dots capable of emitting one of the primaries may be excited by electrons from one gun independent of the excitation of the remaining two kinds of dots. It is possible in the tricolor tube to use juxtaposition and obtain the effect of superposition. The eye blends the colors even at a close viewing distance because of the smallness of the phosphor dots.

The third requirement, a means of controlling the amount of primary light to be added at each point in the reproduced picture, may well start back at the camera. In the case of the RCA color camera presently used, light from the scene to be televised is separated into red, green, and blue components and each component focused on the photo-cathode of a different image orthicon camera tube. The picture is then stored in the form of charge patterns on the target structures of the three image orthicons until taken off by scanning beams traversing the targets in usual television fashion. The signal obtained from one of the camera tubes then contains the brightness information to be fed to the particular gun in the tricolor tube controlling the excitation of the proper set of phosphor dots. When the output of the three camera tubes is properly fed to the grids of the three guns in the tricolor tube, the excitation of the three primaries in the tricolor tube will be of the proper amount at each point in the picture to reproduce the scene being televised.

THE 3-GUN TRICOLOR TUBE

FIGURE 1 is a cross-sectional diagram of the 16-inch color tube showing the major parts and their relative positions. The external metal envelope is made in two parts with flanges so that when placed together the two parts may be joined by a weld. The face plate of clear glass is

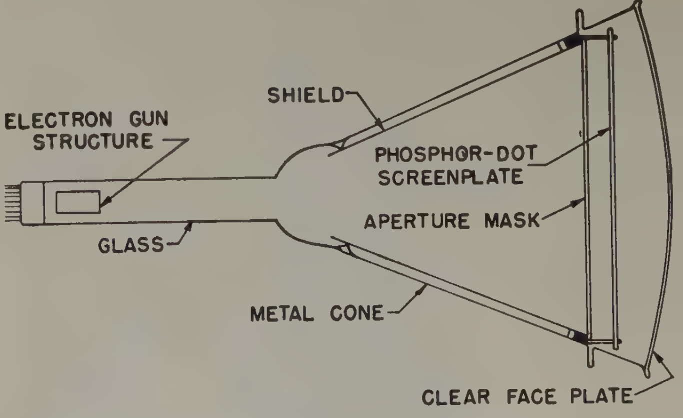

Figure 1. Cross-sectional diagram of the shadow-mask color kinescope showing major parts and their relative positions

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* The shadow-mask tube has undergone intensive investigation with many people participating in various phases of its development. An account of their work will be found in the October 1951 issue of The Institute of Radio Engineers' *Proceedings*. For this article, the author has drawn freely on these published articles, as well as unpubished reports, and gratefully acknowledges, further, the full support and encouragement hat has been given by Dr. D. W. Epstein and Dr. V. K. Zworykin.

Revised text of a conference paper recommended by the AIEE Electron Tube Subcommittee and presented at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952.

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sealed in place before the weld is made as is also the glass neck.

Just inside the outer envelope a high permeability metal cone is fastened to shield the electron beams from the earth's magnetic field as well as other stray magnetic fields. Near the face plate is mounted the mask-phosphor screen assembly. It is for the purpose of inserting this assembly that the cone is constructed with flanges for a welded seal. The mask is on the gun side.

Mounted in the neck of the tube is the gun assembly, shown in Figure 2. There are three single parallel guns spaced equidistant from and at angles of 120 degrees about the assembly. The main lens for focusing the beam of each gun is between grids *3* and *4*. The grid *4* cylinders of each of the guns open up into a single large cylinder, through which all beams travel. Grid *4* is called the converging electrode because, when the gun is in use, the lens action between the large cylinder and the conductive coating on the neck of the tube is used to converge the three beams on the aperture or shadow mask. Some focusing action on the three beams takes place, but the main function of the lens is to bring the beams together on the shadow mask.

Separate leads are brought out through a 14-pin base for the three cathodes and control grids. The three screen grids are also brought out separately to permit adjustment of individual drive characteristics. There is a common pin for the three first anodes, and the three heaters are connected in parallel to two base pins.

Figure 3 shows an exploded view of the viewing screen assembly for the 16-inch color tube. There are three major parts: the mask, spacer frame, and phosphor-dot plate.

The aperture mask is made of thin sheet supernickel alloy, the area inside the border being covered with an array of regularly spaced holes. In the mask shown in Figure 3, these holes are 0.009 inch in diameter and spaced 0.023 inch apart for a total of about 195,000 holes in the picture area. There is an alignment hole and slot in the mask and a corresponding hole and slot in the spacer frame. The spacer frame provides the desired separation between mask and phosphor dot plate.

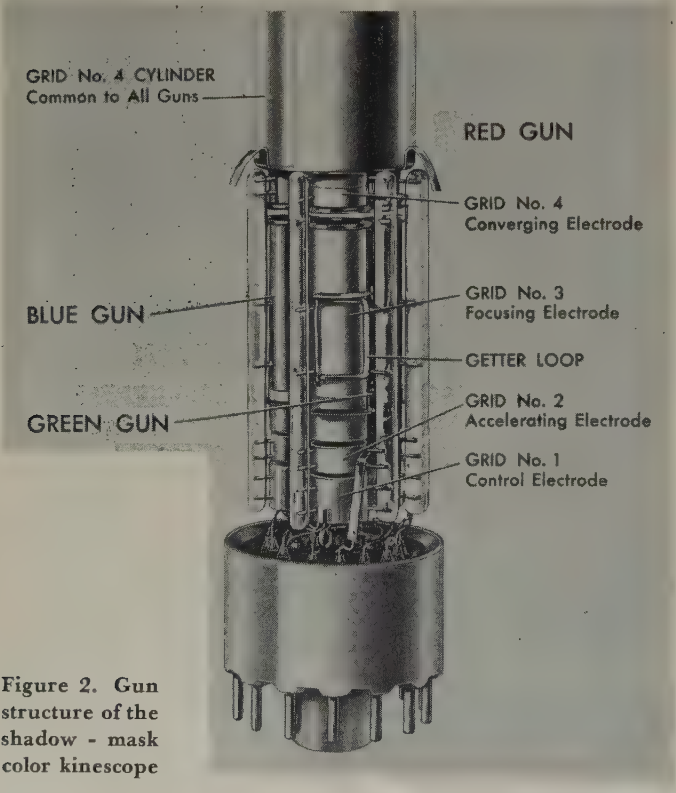

Figure 2. Gun structure of the shadow - mask color kinescope

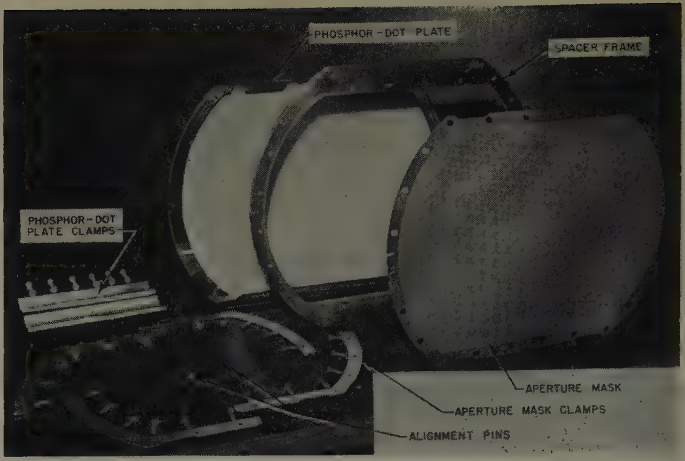

Figure 3. Exploded view of viewing-screen assembly for the shadow-mask color kinescope

The glass plate which is to receive the phosphor screen is cut to match the outer contour of the frame, and drilled near both ends of its horizontal center line to receive alignment pins that go through the alignment hole and slot in the spacer frame and mask.

TUBE OPERATION

As THE NAME implies, the metal mask in front of the phosphor screen serves to mask or prevent the electron beams from reaching the phosphor screen except when the beams are going through the small holes in the mask. The successful operation of the masking principle for reproducing television pictures in color depends on being able to cause the individual electron scanning beams to strike one kind of phosphor only when they reach the phosphor screen. It has been possible to solve the problem because a scanning beam may be considered, to a sufficiently good approximation, as originating from a point and as traveling in straight lines from that point to the phosphor screen. The point may be called the center of deflection of the beam, and if more than one beam goes through the deflection yoke, the centers of deflection define a plane that is normal to the axis of the deflection yoke and lies somewhere near the center of the yoke.

If three beams in going through the yoke pass through the corners of an equilateral triangle in the deflection plane and converge to a point on a mask placed in front of a phosphor screen, then an arrangement of holes in the mask may be found that permits each beam to strike separate areas on a phosphor screen beyond the mask such that the areas nest together perfectly. The geometry involved is shown in Figure 4 where the axes of three beams passing through deflection centers are shown going through one hole of the mask and falling on phosphor dots in the plane of the phosphor screen. The holes in the mask are placed at the apexes of equilateral triangles that are oriented in such a way with respect to the deflection plane triangle that the phosphor dots, when in the appropriate places, all nest together perfectly. The relation between the mask holes and the phosphor dots is more clearly shown in Figure 5. The orientation of the beams in the deflection plane is not shown but may be visualized by imagining how the beams would have to go through the mask holes to hit the phosphor dots.

The geometrical properties of the viewing screen assembly are of sufficient importance to be considered a little further. Since the holes in the mask are placed at the apexes of equilateral triangles, there are three directions in the pattern in which well-defined rows of holes appear with the holes spaced apart a distance equal to the side of the equilateral triangle. Figure 6 shows a section through a color center and one of these rows of holes in the mask. The color center O is on the left and an edge view of the mask and phosphor screen is on the right. As indicated the distance between the centers of the mask holes is a constant and here denoted by a. Also, the mask is parallel to the phosphor screen and is located at a distance q from the screen. If we consider the triangles made by drawing lines from the color center through the centers of all the mask holes to the phosphor screen, then it is evident that a number of triangles are formed all of which have the same altitude L. Consider now the upper triangle. By simple geometry, $D/a=L/L-q$. The same proportion holds for each of the triangles and since a, L, and q remain constant, all the D's must be equal. The D's represent the center-to-center spacing of the correct phosphor dot positions, which means that the phosphor dot pattern consists of dots uniformly spaced from one side of the screen to the other. In fact, the phosphor dot pattern is the same as the mask pattern but enlarged by the factor $L/L-q$.

The practical significance of the fact that the phosphor positions are equally spaced for one of the colors is that if a stencil can be made for depositing the phosphor of one color, then the appropriate shift of the stencil will enable the phosphors of the second and third colors to be located, because the three phosphor patterns are identical and nest perfectly together.

So far, in discussing the geometry of the tube, each electron beam has been considered as originating from a point source at its center of deflection, as shown in Figure 7. This implies that the holes in the mask may be nearly equal in size to the phosphor dots. Since the electron beam at the center of deflection may have an appreciable diameter, the mask holes will have to be reduced from the size they could be in the point source case in order to obtain proper shadowing action at the phosphor screen. To study the effect, a simple approximation is to assume that electrons originate and travel in straight lines from a disk that represents the cross section of the beam at the center of deflection, Figure 8. Assume that peripheral rays define the electron beam as it goes through the shadow mask to the phosphor screen. In Figure 8 only one of the electron beams is shown together with one row of mask holes and the phosphor dots associated with that row. R is the phosphor dot diameter when the 3-color array consists of tangent dots, D is the distance between dots of the same color, a is the distance between aperture holes of diameter B. M is the diameter of the disk that is assumed to be the source of electrons, and the disk is located a distance S from the tube axis.

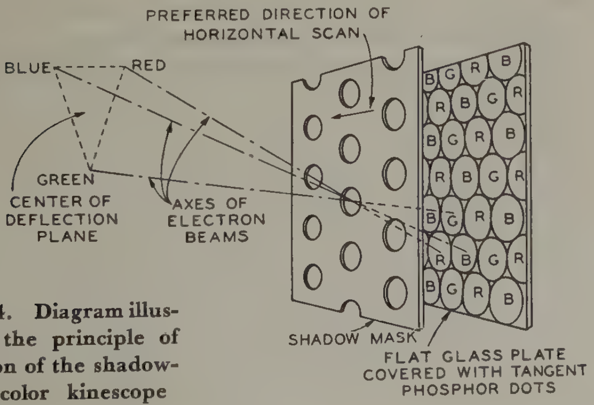
PREFERRED DIRECTION OF HORIZONTAL SCAN
BLUE
RED
GREEN
CENTER OF DEFLECTION PLANE
AXES OF ELECTRON BEAMS
B
G
R
SHADOW MASK
FLAT GLASS PLATE COVERED WITH TANGENT PHOSPHOR DOTS

Figure 4. Diagram illustrating the principle of operation of the shadow-mask color kinescope

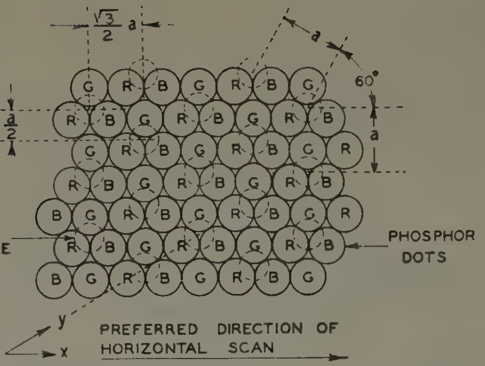

Figure 5. Phosphor-dot array used in the shadow-mask color kinescope. The relation between the shadow-mask holes and the phosphor dots is shown for a region near the axis of the tube

Now the problem is to find the consequence of changing the beam width in the deflection plane from a point to some diameter M. Without going into geometrical proof it can be seen that if M goes to zero, the mask hole diameter becomes a maximum. As M goes from a point to some value M, the peripheral rays require a smaller mask hole, and if the geometry were considered carefully it would be found that as the value of M got large enough so that this disk, together with disks for the other two beams not shown, became tangent, then the mask holes for proper shadowing would be zero. Zero mask hole diameter means zero electron current to the phosphor screen, while $M=0$ means zero current in the beam. Therefore, there must be an optimum value of M and B that will allow maximum beam current to get to the phosphor screen. The optimum values will depend, of course, on the current distribution across M, so an answer cannot be found for the size of M and B until further assumptions have been made about the current distribution in the beam.

The problem is not quite so simple, however, for there is another variable, S, the distance of the beam from the tube axis. The value S is related to the convergence angle of the beams or the angle between each beam and the tube axis. It can be seen that if $S=0$, $M=0$ and again

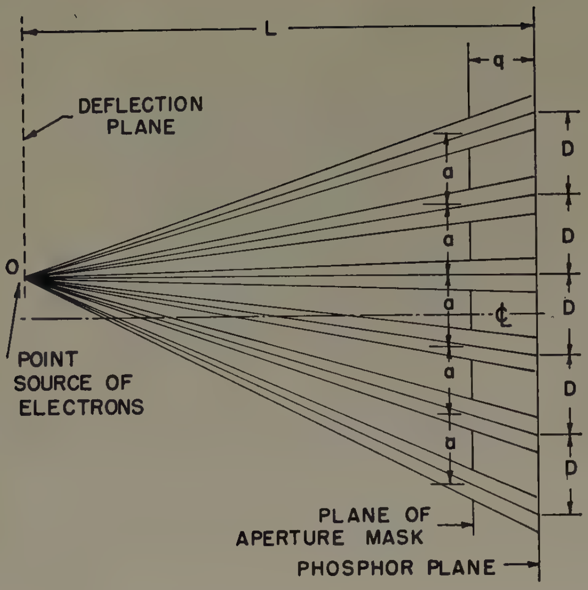

Figure 6. A plane through an axis normal to the plane of the phosphor array and passing through a color center, O, in the shadow-mask color kinescope

no beam current is possible. However, as *S* becomes larger *M* and *S* may take on values. The larger *S*, the larger *M* or *B* may become, and consequently, the more beam current may strike the phosphor screen. The conclusion is, then, that the convergence angle, when small, may limit the beam current that can be obtained. There is a reason, however, for keeping the convergence angle as small as possible. If a single deflection coil is to be used, the deflection of the three beams will be more nearly alike the closer the beams are together. A value that has been found practical for the convergence angle is about 1 degree.

MAKING THE TUBE

DIFFERENCES IN the color tube and black-and-white kinescopes require additional engineering and manufacturing techniques, but they are of such a nature that if adequate manufacturing care and diligence are pursued, production of the color kinescope will impose no more serious problems than those which were experienced in the early days of black-and-white kinescope production. A number of techniques and processes have been worked out to produce shadow-mask color tubes.

The metal mask consists of a large number of holes in a sheet of thin metal with the holes uniform in size and equally spaced. Very satisfactory results have been obtained for pilot-plant production of tubes by etching the holes in the masks from rolled metal strips.

The mask is fastened to the spacer frame by means of clamps held by screws. It is important that the mask be under tension on the frame in order that it be held accurately in position with respect to the phosphor screen. As readily may be visualized, a change in the distance between the mask and phosphor screen, particularly near the edge of the picture, would cause color dilution because the beam would strike too far from the axis of the tube or too near, depending on whether the mask to phosphor-screen distance was too great or too small. A second factor is that the mask may be operated at a higher temperature before looseness occurs if it is initially stretched near its elastic limit. The operating temperature is somewhat higher than room temperature because of the beam power absorbed.

The mask tension may be controlled at the time of mounting by what has been called hot blocking. Heated platens are placed in contact with the mask, but the frame remains cool. While the mask is hot and thus expanded the clamping screws are tightened. When the mask is cooled it contracts and develops a tension that depends on the temperature to which it was raised.

After the mask has been mounted, the next operation is the making of the phosphor screen. As was described earlier, the electron beam may be considered as traveling in a straight line from a point in the deflection plane. It is therefore possible to simulate the electron beam by a point-source of light and to locate the correct phosphor dot positions on a photographic plate placed in the plane where the phosphor screen is to be mounted. The apparatus used to perform these operations has been called the lighthouse. Figure 9 shows a schematic drawing that illustrates the apparatus. The mask-spacer frame assembly is placed with the mask down on locating points, not shown, for the purpose of accurately positioning the assembly with respect to the point light source below. A Kodalith plate is placed on the assembly with the emulsion towards the mask, so that the emulsion is in the same plane as the phosphor screen will be later. The point light source is located a distance below equal to the desired distance between the mask and deflection plane in the finished tube. Since the point-source automatically fixes one of the color centers of the assembly at its own location when the exposure is made, it is important that the point-source be positioned not on the axis of the as-

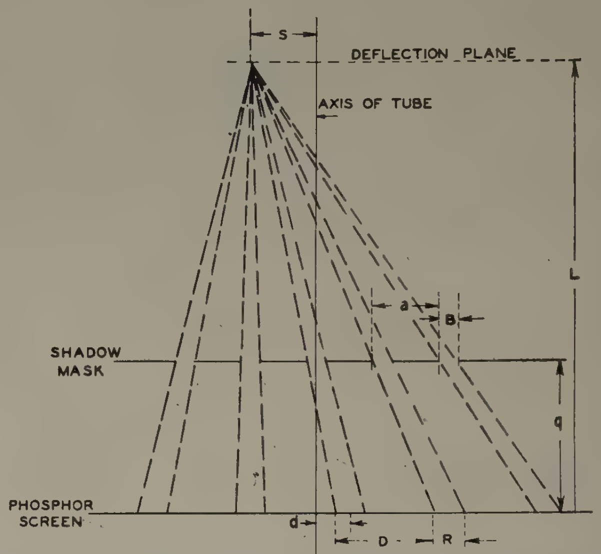

Figure 7. A plane perpendicular to the shadow mask and passing through a row of holes in the y direction as defined in Figure 5. The geometry for a point source is shown

sembly, but off the axis a sufficient amount to give the required angle between the beam and the axis. The position of the point-source about the axis is also important in order that the correct angular relation between the mask array and the guns ultimately may be obtained.

As the exposure is made there are recorded on the Kodalith plate the positions where phosphor dots of a particular kind should be placed in order that all dots of that kind may be struck by the beam as it scans. At the same time, the alignment hole and slot are recorded on the plate as a guide to be used in positioning the phosphor plate when the phosphor dots have all been applied to form the screen.

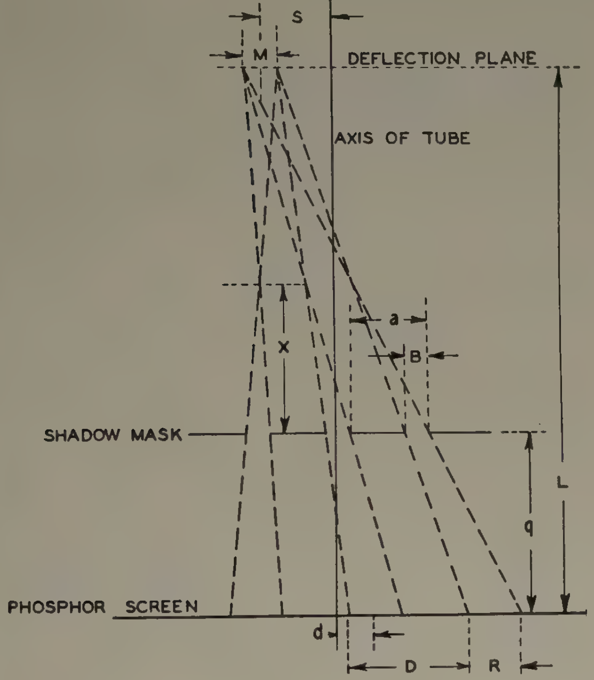

Figure 8. A plane perpendicular to the shadow mask and passing through a row of holes in the y direction as defined in Figure 5. The geometry for a source of diameter M is shown

From the Kodalith plate with the dots on it, or even directly from the lighthouse, one may proceed to make the phosphor screen in a number of ways, for example, by electrostatic printing, photo printing processes, offset printing, silk screening, and settling. However, only the process will be described that has been most extensively used in pilot production, namely, the silk-screen process.

In general, the silk-screen process of printing consists of blocking the openings to make a stencil out of a piece of cloth or metal mesh. The holes are blocked by a gelatin layer placed where there is to be no printing. Ink then may be forced through the clear parts of the fabric to the surface to be printed by means of a squeegee drawn across the fabric with the ink being pushed ahead of the squeegee.

The actual printing is done on a table fitted with a vacuum mechanism for holding the glass to be printed. Also, there is a crossfeed arrangement for moving the glass in two directions underneath the stencil, the amount of movement being indicated by dial gauges. The stencil is placed over the glass and its mechanism and held stationary. Movement of the glass with respect to the stencil is used for initial alignment of the pattern with the two holes in the glass as well as shifting the glass under the pattern to get the correct position for printing the second and third phosphor arrays. The movement for changing to another phosphor array is about 14 mils.

The printing ink or paste is made by dissolving ethyl cellulose in amyl alcohol and then adding the phosphor powder. Since the same stencil is used for printing each of the three types of phosphor, a thorough cleaning of the stencil after each printing is required in order to keep from mixing phosphors.

After one phosphor array has been printed the phosphor plate and corresponding mask assembly are put back in the lighthouse to check the positions of the dots visually. The three colors are then printed and the plate is baked in air for one hour at 400 degrees centigrade to remove the ethyl cellulose binder. After the bake, a silicate solution is sprayed on to act as a binder to keep the dots from coming off in the subsequent steps of aluminizing. These steps consist of floating an organic film onto the phosphor surface in a tank of water, evaporating aluminum on the film, and air baking to drive out the organic film. When these steps have been completed, a thin continuous film of aluminum covers the phosphor screen.

The parts are now ready for final assembly of the viewing screen. A steel alignment pin is pressed into the alignment hole in the spacer frame. The diameter of this pin is matched with that of the hole in the phosphor-dot plate which is to fit over it. Next, an alignment bolt is fitted through the opposite hole in the phosphor-dot plate and the slot in the spacer frame. Slippage along the horizontal axis, therefore, is permitted to the extent required by the differential expansion between glass and metal, which occurs during tube bake-out. It is to provide for this differential expansion that the slot is used, while insuring that the original alignment be restored after the heating cycles in making the tube are over.

The 3-gun assembly is sealed into the neck, the viewing-

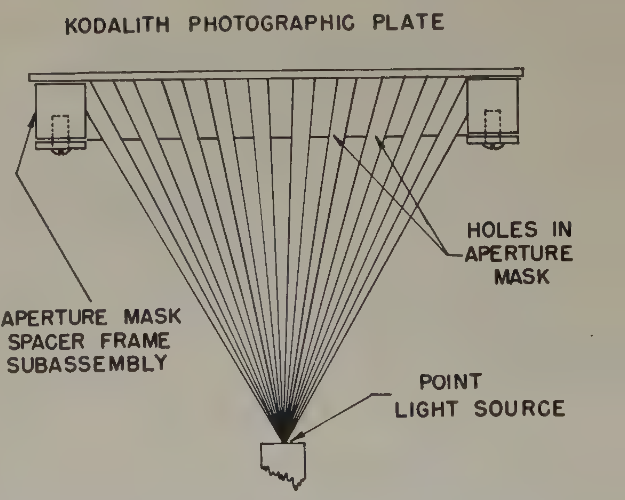
KODALITH PHOTOGRAPHIC PLATE
HOLES IN APERTURE MASK
APERTURE MASK SPACER FRAME SUBASSEMBLY
POINT LIGHT SOURCE

Figure 9. A schematic drawing illustrating how a light source is used to simulate one of the electron beams

screen assembly is bolted to support posts in the lower cone and the upper cone put in place for the final welded seal. After the final seal the tube is exhausted by modified cathode-ray-tube methods. Reduced heating and cooling rates are desirable to avoid breakage of the phosphor-dot plate from thermal shock and overstretching of the shadow mask due to too large a temperature differential between the mask and frame.

OPERATING CHARACTERISTICS

In figure 10 are shown the maximum operating voltage ratings. It will be noted that dynamic focusing and convergence voltages are used. They consist of superimposed voltages that keep the beams focused and converged at all points on the flat phosphor screen.

For satisfactory performance it is essential that there be no color shift with variation in intensity of light output. Since the phosphors show negligible current saturation in the range of current densities used, the necessary constancy of color requires that the ratios between the final electrode currents from the three guns be held constant over the desired brightness range. When the tube is used to reproduce black-and-white pictures, it is particularly important that the color temperature remain constant for the various shades of gray in the picture to prevent color tinting of the highlights and shadows. Obtaining of proper reproduction of black-and-white pictures is a condition for proper reproduction of color pictures.

To produce a white of approximately the same color temperature as that produced in a conventional black-and-white kinescope, it is necessary to have about three times as much current from the red gun as from the blue or green gun. One method of driving the three guns involves the use of separate video gain controls on each of the amplifiers driving the control grids so that the drive can be adjusted as required. Higher drive for the red gun will be required with the present red phosphor. With this method, the control grid cutoff voltage is adjusted to about the same value for the three guns by varying the screen-grid voltages.

Another method of driving the guns involves the use of equal-gain video amplifiers with a common master control. With this method, the screen-grid voltages are adjusted to produce a low cutoff voltage for the red gun and a relatively high cutoff voltage for the blue and green guns. Adjusting cutoff in this manner will increase the sensitivity of the drive characteristics of the red gun as compared with that of the blue gun or the green gun and, hence, will produce the desired ratio of currents to give white. This method requires a greater range in the control-grid and screen-grid supply voltages than the method utilizing separately adjustable driving voltages.

It was stated earlier that the mask operates somewhat above room temperature because of the beam power absorbed. For 20,000 volts on the final electrode, an average current of the order of 300 microamperes may be used or of the order of 6 watts. This permits a peak current of 800 microamperes or more on average scenes. It has been found that under these conditions the temperature rise of the mask does not cause a shift of the mask by an amount sufficient to cause color dilution.

Highlight brightnesses of 50 foot-lamberts have been obtained with the shadow-mask color tube, but on the average the tubes at this time are operated at a somewhat lower brightness.

Turning now to the matter of resolution as influenced by the dot structure of the phosphor screen, there are perhaps two aspects to be considered. The first is the texture of the picture. To be sure, if one gets close enough to the phosphor screen the dot pattern can be seen. However, the structure is not visible at normal viewing distance. The other aspect is the resolution capabilities of the phosphor screen. Results obtained on a 16-inch tube indicate that substantially all the resolution can be seen on a test pattern that would be expected with a 4-megacycle bandwidth. Tests performed when no bandwidth limitation existed show that the tube is capable of a horizontal resolution of between 325 and 400 lines and a vertical resolution of between 350 and 450 lines. The fact that the vertical resolution is higher than the horizontal resolution is due primarily to the geometrical property of the pattern of dots. The resolution can be increased rather easily of course by increasing the number of dots. This has already been done in the 21-inch tube recently demonstrated in New York.

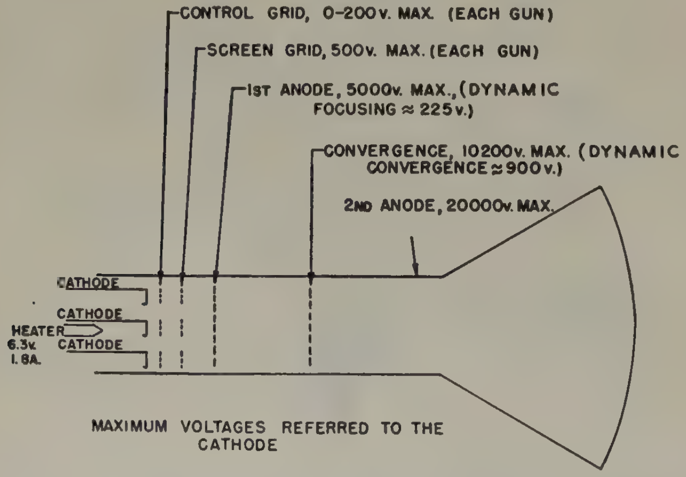
CONTROL GRID, 0–200V. MAX. (EACH GUN)
SCREEN GRID, 500V. MAX. (EACH GUN)
1ST ANODE, 5000V. MAX., (DYNAMIC FOCUSING ≈ 225V.)
CONVERGENCE, 10200V. MAX. (DYNAMIC CONVERGENCE ≈ 900V.)
2ND ANODE, 20000V. MAX.
CATHODE
CATHODE
HEATER
6.3V.
1.8A.
CATHODE
MAXIMUM VOLTAGES REFERRED TO THE CATHODE

Figure 10. Maximum operating voltages for the shadow-mask color kinescope

CONCLUSION

In conclusion, it may be emphasized that the technical developments leading to improved kinescopes, particularly since World War II, have formed the groundwork to which have been added techniques particularly applicable to color tubes. A color tube has been built and put into pilot-plant production that is capable of giving bright, well-resolved pictures with excellent color separation. Each of the three primary images in the reproduced picture is separately produced by an electron beam. The use of a shadow mask insures that beam focus does not influence color while a single deflection yoke for the three beams eliminates the need for precision scan.

REFERENCE

1. Methods Suitable for Television Color Kinescopes, **E. W. Herold.** *Proceedings*, Institute of Radio Engineers (New York, N. Y.), volume 39, number 10, October 1951, pages 1177–85.

A Series Magnetic Amplifier With Inductive Loading

T. G. WILSON
ASSOCIATE MEMBER AIEE

The circuit examined is the series-connected magnetic amplifier of Figure 1. This circuit has been the subject of many analyses; however, in almost all instances simplifying assumptions were made concerning the magnitude of some of the circuit parameters, but very little work has been done on circuits in which L_a and L_d were not zero. This article analyzes and discusses the changes in current waveshape produced by variation of the circuit parameters E_d, R_d, L_d, R_a, and L_a.

To understand these changes, the circuit is analyzed mathematically. The assumptions which were made in the analysis are

1. The winding resistances are combined with the external circuit resistances to determine R_a and R_d.
2. The distributed and interwinding capacitances are negligible.
3. The magnetic leakage is negligible.
4. The constraint relating the flux in a core to the total ampere-turns acting on the core is a curve composed of three straight-line segments.

In the solution two types of discontinuities occur. One type of discontinuity is encountered when one of the parameters, for example, the control voltage E_d, is changed externally. The other type is encountered when operation proceeds from one segment of a magnetization constraint curve to the next segment. At this latter type the mode of amplifier operation changes. Four such modes are defined. For each, solutions for i_a, i_d, ϕ_{I}, and ϕ_{II} are obtained by simultaneously solving the circuit voltage equations and the mode constraint equations. The solutions so obtained are tabulated and are used to predict the instantaneous values of the currents and fluxes which exist throughout transient and steady-state conditions. Figure 2*A* shows an oscillogram of the transient response of an amplifier, while Figure 2*B* compares the experimental load circuit current wave of *A* with the corresponding calculated wave.

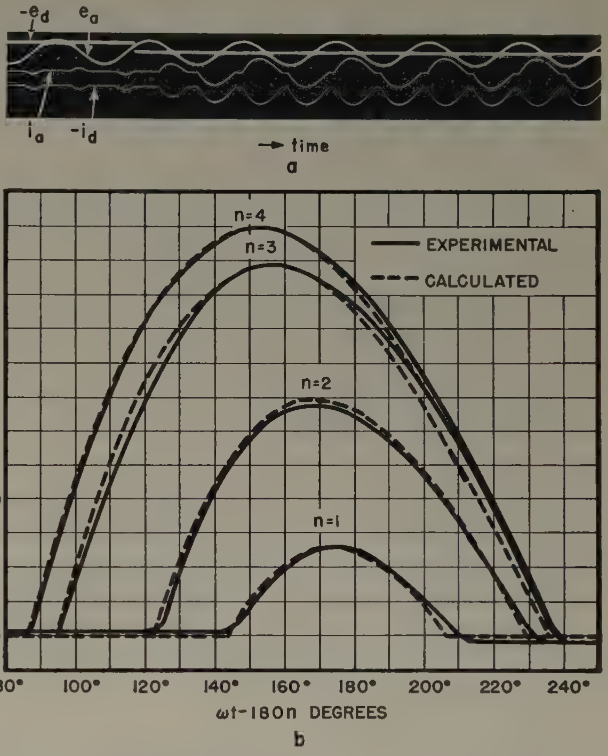

Figure 2(A). Oscillogram of transient currents and voltages when E_d is increased from 1.32 to 15.3 volts. (B). Initial steady-state load circuit current wave, when $E_d = 1.32$ volts ($n = 1$), and the first three half cycles ($n = 2$, 3, 4) of the transient current wave, when E_d is changed from 1.32 to 15.3 volts at 212 degrees

From the analysis and subsequent experimental verification it is shown that the presence of linear inductance in either circuit causes change in the current waves from those which exist in purely resistive circuits. Also, over a wide range the steady-state current waveshapes depend upon the sum of the inductances in the two circuits and not upon the division of the inductance. The limit of this range can be determined from calculations of certain critical values of total inductance above which there are two new states of operation depending upon the division of inductance between the two circuits. No such generalization, however, may be made concerning the circuit resistances; the current waveshapes are found to be changed in different manners by changes in R_a and R_d.

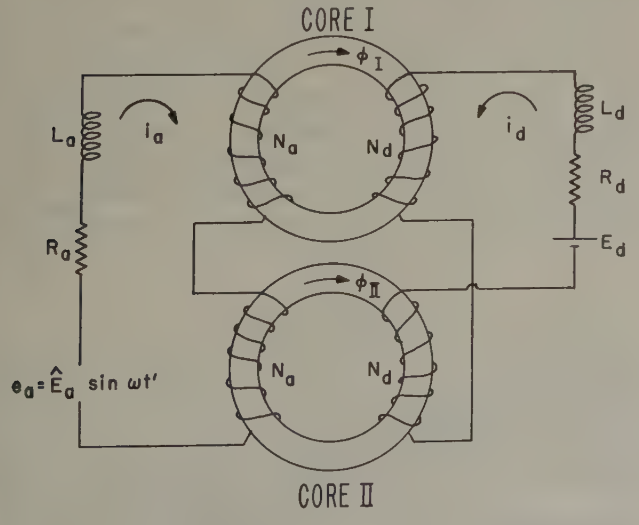

Figure 1. Series-connected magnetic amplifier circuit

Digest of paper **52-94**, "Series-Connected Magnetic Amplifier With Inductive Loading," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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The Calculation of the Magnetizing Force

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A GRAPHICAL CALCULATION of the magnetizing force H makes it possible to find the values of induction, short-circuit forces, and so forth, easily.

The method is as follows and is intended to find the numerical value of a component $\boldsymbol{H}_h$ of the magnetizing force $\boldsymbol{H}$ pointing from the point 0 into the direction $\boldsymbol{h}$ and due to the electric current I flowing in the section s of a circuit. See Figure 1.

1. Project the section s onto the plane set in the point 0 normal to the direction $\boldsymbol{h}$.
2. Take all the radii vectors $\boldsymbol{r}_g$ pointing from the point 0 to the points of that s_g projection. Build simultaneously their mates ρ_g unidirectional with the $\boldsymbol{r}_g - s$ but $\rho_g = r_g/r^{3/2}$ long.
3. Measure the area A_h swept over by ρ_g while ρ_g follows the rotation of $\boldsymbol{r}_g$ from one endpoint to the other one of the s_g projection.

The component of the magnetizing force in the direction $\boldsymbol{h}$ has the numerical value

$$H_h = 2IA_h \tag{1}$$

All three components of $\boldsymbol{H}$ pointing into the three directions of the space can be worked out similarly. The total magnetizing force is the vectorial sum of those components.

The mechanical force F_y acting on a length l of an electric circuit carrying the current I_l in the field of H_x has a value (in Newtons) of

$$F_y = 10^{-7} I_l H_x l \tag{2}$$

The numerical calculation is simple if the meter-kilogram-second system is used.

The method has the well-known advantages of the graphical calculation. It renders an easy and continuous check of eventual errors as the calculation proceeds. It makes it possible to predict the effect of an intended alteration in the arrangement of the conductors. It discloses immediately the contribution of any section of a circuit to the resulting magnetizing force, and makes it possible to calculate the value of a component of the magnetizing force in a deliberately chosen direction.

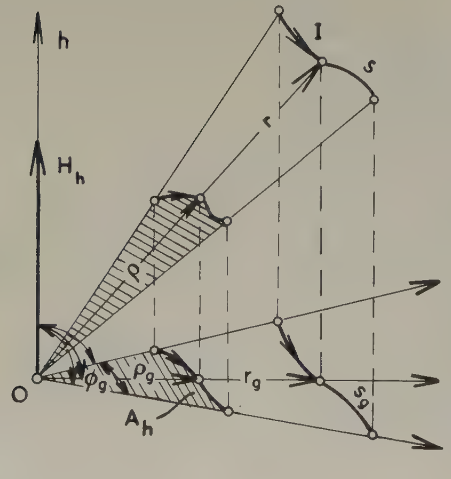

Figure 1. The construction of a component of H in the direction h. The plane of g and s_g is normal to h

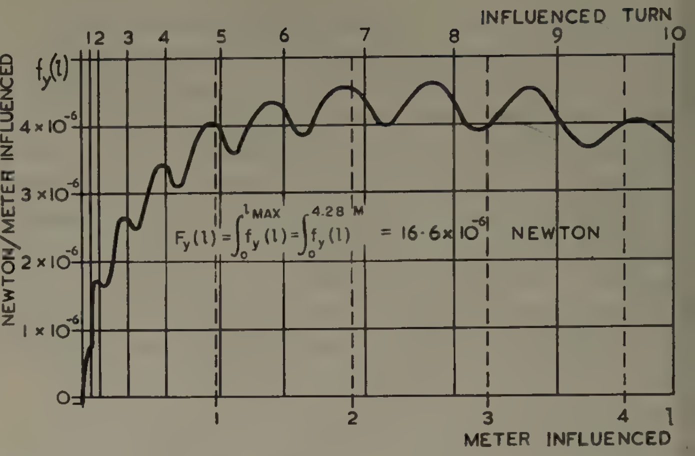

Figure 2. The force f_y (l) per meter acting distributed on the primary winding of a current transformer and due to the current flowing in a second current transformer similar to the first one and fitted in the neighboring phase. One ampere is supposed in the windings of both current transformers

The application of the new method can be demonstrated by the calculation of the distribution of short-circuit forces. Such short-circuit forces are limiting the use of wound-type current transformers in industrial switchgear. Existing formulas enable the calculation of the total force acting on the total winding as an entity only; however, they disclose neither the distribution of those forces nor the contribution of the various parts of the influencing winding to those forces. Furthermore a small error in those very complex calculations may have a very big influence on the final result and without any possibility of a check.

The presented method gives all the requested information in a visual representation and with the possibility of a continuous check. Results of such a calculation are in Figure 2, showing the mechanical force along a 10-turn primary winding of a current transformer and due to the magnetic field of a similar current transformer in the neighboring phase. A unit current of 1 ampere is supposed in each winding.

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Reliability of 28-Volt D-C Aircraft Distribution Systems

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An analysis of protection of a typical 28-volt d-c distribution system for large multiengine aircraft is presented. Conclusions regarding bus and feeder fault protection and arrangement are included.

PRESENT-DAY aircraft are dependent for best operation on the reliable, continuous service of their electric systems. The design, installation, and maintenance of these systems must be kept within certain standards in order to achieve the desired results. The importance of protecting the system by an integrated fault protection design and a well-disciplined program of installation and maintenance cannot be overemphasized.

Figure 1 shows diagrammatically the equipment and circuits of the system analyzed in this article. In general, it consists of six generators, two batteries, and a centralized bus system, protected primarily by the use of current limiters. Detailed descriptions of systems similar to the typical one analyzed herein may be found in previously presented articles.[1,2]

In preparing or checking the fault protection of an electric system, it is necessary to consider at least three types of faults:

1. Continuous short circuits.
2. Continuous arcs with arc voltage 14 to 20 volts.[3]
3. Intermittent arcs.

Continuous short circuits, or solid faults, may occur as welded faults, may result from mechanical failure of a bus structure, or may be caused by the failure of some other protective device. This type of fault presents a severe problem in systems using self-excited shunt machines because of the low generator current available for clearing the fault at the low fault resistances involved. This steady-state current ranges from about 200 to 500 amperes per 300-ampere generator.

Continuous arcs, if maintained, are more easily cleared because the voltage involved (14–20 volts) moves the operating point on the generator volt-ampere curve toward the knee of the curve and the fault currents are in the range of 500 to 1,000 amperes per 300-ampere generator. It is possible that a fault of this type will burn clear before the limiter is able to clear the circuit.

Intermittent arcs are not analyzed in this article. In previous investigations, the fault currents under such conditions were so low that limiters could not detect the fault. To protect from this type of fault, differential or balanced current devices may be necessary. Differential protection is now being applied to some important circuits, such as the generator circuit, but has not been applied generally to the distribution circuits.

CRITERIA FOR SYSTEM PROTECTION AND OPERATION

THE DESIRED characteristics of a fault protection scheme should include:

1. Faults should be cleared as quickly as possible and should be interrupted before damage is done to system components.
2. Protective devices should isolate only the faulted section, thereby retaining the maximum amount of available feeder and generator capacity.
3. A well-protected system should have adequate backup protection in the event of failure of any one of the protective devices.
4. The system should operate without false or nuisance trips.
5. Satisfactory performance, as stated above, should be maintained even with the prior loss of some capacity and/or the loss of certain feeders.

Fast operation of protection will minimize the fire hazard concurrent with faults and will give greater system reliability. Efforts have been made in the past and will be made in the future to lessen the operating time and improve the selectivity of protective devices. Backup

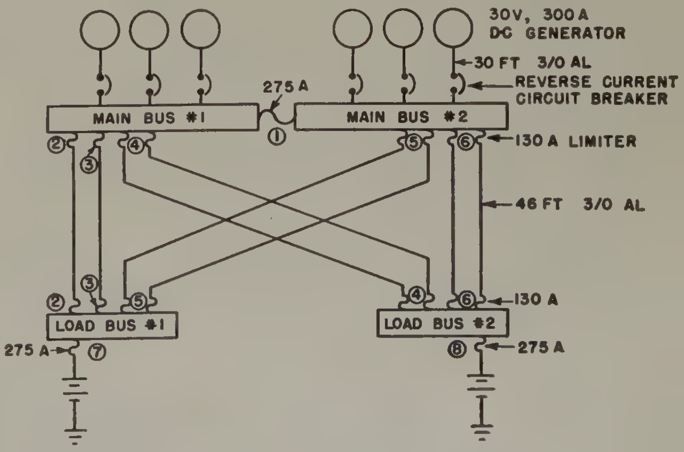

Figure 1. System diagram

Revised text of paper 52-132, "Distribution System Reliability of 28-Volt D-C Aircraft Electric Systems," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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protection may be considered as insurance to protect against faulty devices elsewhere in the system.

The criteria of having the system operate under conditions of reduced capacity and inoperative feeders is an important safety factor consideration. Aircraft operators, in their operating procedures, may allow take-off with one of six generators inoperative and it is possible that on the same flight another may fail. Protection for this condition must be provided for, just as it must be when one or more feeders may not be available for use because of a previously cleared fault.

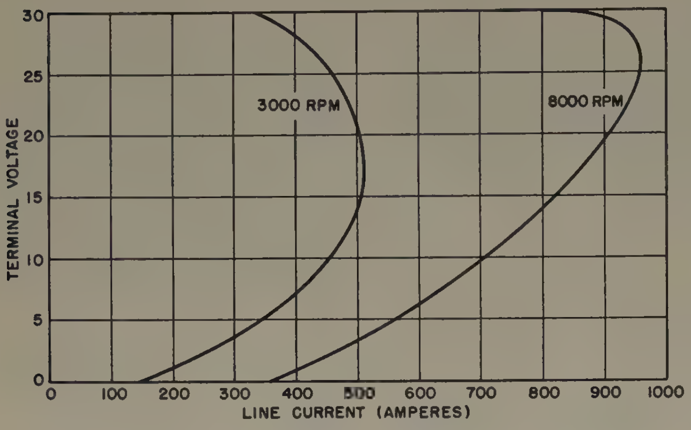


Figure 2. Volt-ampere curve (30-volt 300-ampere d-c generator)

METHOD OF STUDY

Ratings of Protective Devices. The sizes of the fault protective devices are largely determined by the magnitude of load carried by them during normal, abnormal, and emergency operation. Therefore it is usually necessary to make a load study of the system before fault protection elements can be chosen. Then from the results of the fault study, the ratings of the protective elements are adjusted to give the maximum co-ordination.

Load Study. To conduct a load study it is necessary to have a complete picture of the electric loads, their duty cycle, maximum and normal demands, and physical position in the airplane. In addition to load data, and after a preliminary layout of the system, the following information should be available: the size, length, resistance, and current rating of the cables, and the flight condition of the airplane. With this information, an electric circuit can be drawn representing the system. This circuit can be checked for voltage regulation and for current-carrying capacity in each branch, thus determining the limiter sizes. The system should also be checked for specified abnormal or emergency operation. Limiters should be selected to carry the maximum load currents found under emergency conditions, but should be as low a value as possible for fast clearing under faults.

Fault Study. The effect of abnormal conditions on the system are checked by a fault study. In this study, faults should be placed on the system at various positions and the resulting currents in each branch of the circuit noted. Then the limiter time-current curves are consulted to determine the co-ordination of the system. That is, only the part of the system which is faulted should be isolated; the remainder should continue to supply the load.

From this study, the sizes of the protective devices may have to be adjusted to obtain the best co-ordination possible. The results also may indicate the way to a better design or arrangement of busses and cables. The same data are necessary for a fault study as for a load study with two major additions, the time-current curves for the protective devices and the volt-ampere curves which serve as the representation of the generators. The addition to steady-state fault currents from the initial transient can be neglected, if the clearing times of the protective devices are three to four times greater than the time constants of the generators.

Figure 2 illustrates the volt-ampere curve for a 30-volt 300-ampere d-c generator with voltage regulator control. Since it is nonlinear it cannot be represented by any simple mathematical expression. The curves must be obtained by test and accuracy must be maintained especially for the lower part of the curve since the operating point during faults will fall on this part of the curve.

The calculations may be done either by trial-and-error hand solution or by use of the d-c network analyzer.[4] In either method, it is advisable for simplicity to use a per unit system. For use with the d-c network analyzer, the normal source voltage is taken as 1.0 per unit voltage and the normal rating of a generator as 1.0 per unit current.

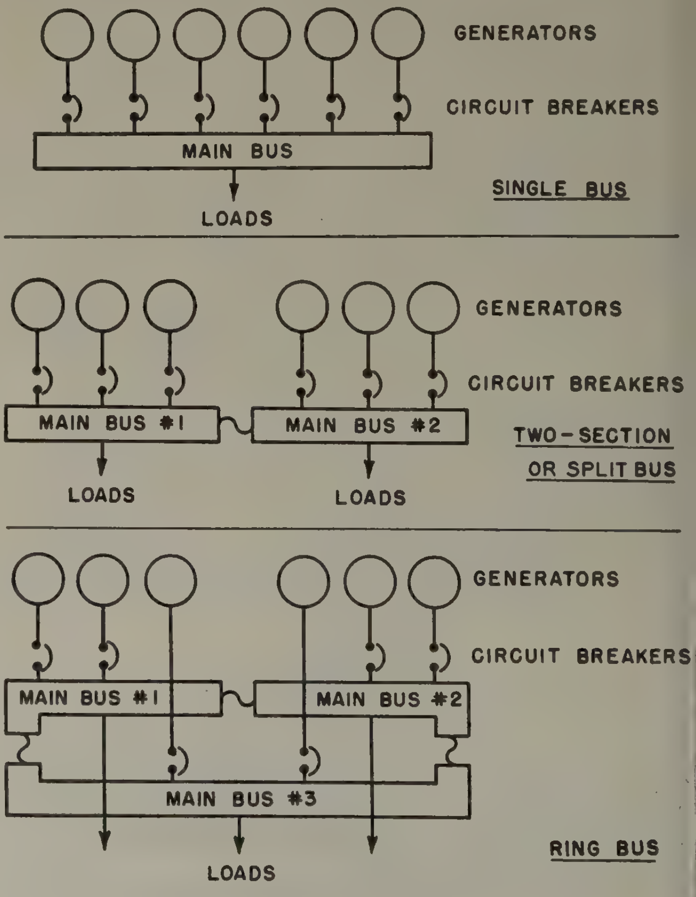


Figure 3. Main bus arrangements

The per unit resistance may be calculated from the per unit voltage and current. In self-excited systems, since the voltage of the generator falls to a low value at short circuit, the highest source voltage is the battery and is represented by a 1.0 per unit voltage behind its internal impedance. The circuit resistances are changed to per unit values and the volt-ampere curves may be combined and also replotted in per unit values. The analyzer ground connection is placed at the point of fault and the resistance representing the generators adjusted to read the proper values from the curves. Currents are read in each line, changed to actual amperes, and checked against the time-current curves to establish which limiter or limiters will melt first. If the other limiters in the circuit had only a small amount of fault current heating them, a second calculation must be made with the first limiter open to establish which limiter opens next. Generally a fault will be cleared by the opening of two limiters or sets of limiters, and thus two sets of calculations per fault are necessary. The total clearing time under these conditions is the sum of the melting times of the two calculations.

If the results warrant changes, the sizes of the protective devices should be altered to obtain the best co-ordination possible for the design. The results may also suggest changes in the arrangement of busses or cable runs which may greatly improve co-ordination and reliability.

DISCUSSION

Bus Configuration. Figure 3 illustrates three types of main busses which we shall refer to as single, 2-section or split, and ring type. The first of these, the single bus, is the simplest. However, its use makes the system extremely vulnerable to a solid main bus fault. Such a fault would cause a loss of the whole system.

The split bus illustrated has the great advantage that a solid main bus fault results in loss of only half of the main bus load. Once the faulted bus is isolated, all loads except those connected to the faulted bus may be carried by the other main bus section. It is important to note that the vital instrument and radio loads ordinarily supplied through the load busses would not be lost. The employment of this type of bus rather than the single bus involves, in most cases, little or no increase in weight or space.

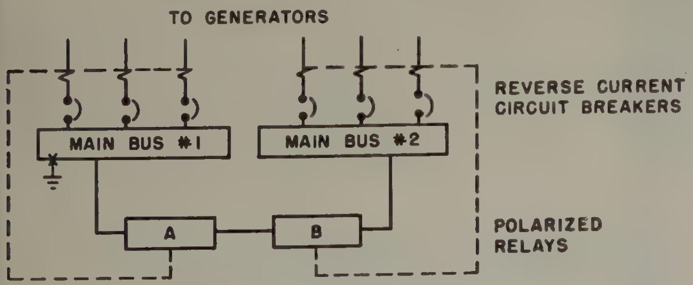


Figure 4. Polarized relay scheme (for removal of generators from faulted bus)

The use of a ring bus further decreases system vulnerability to a main bus fault. On the other hand it increases system complexity with resultant design problems relating to the number, size, and run of cables, and the obtaining of equal division of the main bus load for all conditions of flight and reduced generation operation. If a ring bus is to be used, a check must always be made to determine that the bus tie overcurrent devices will not be opened or damaged by bus tie currents due to unbalanced bus loads, a reduced number of generators on the bus, or a combination of both.

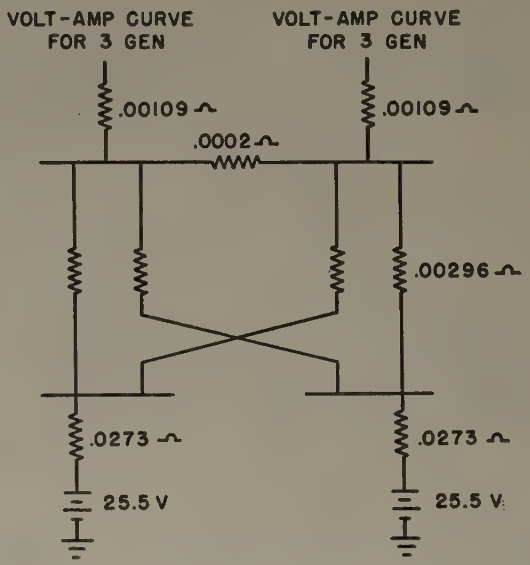


Figure 5. System equivalent circuit

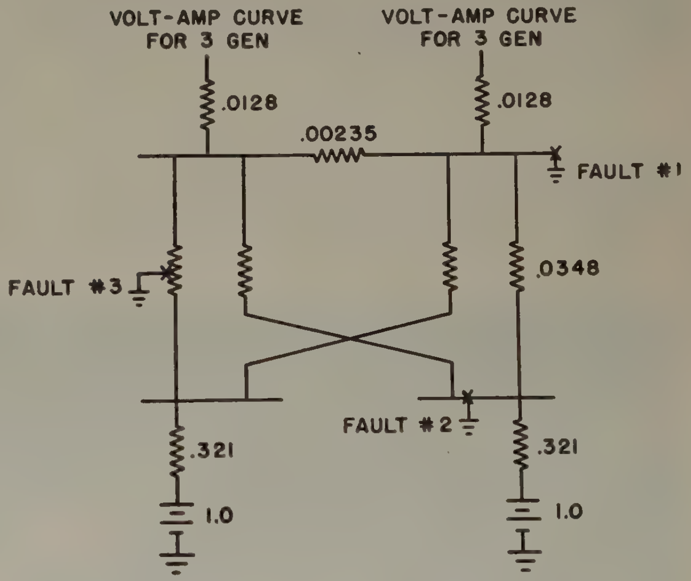
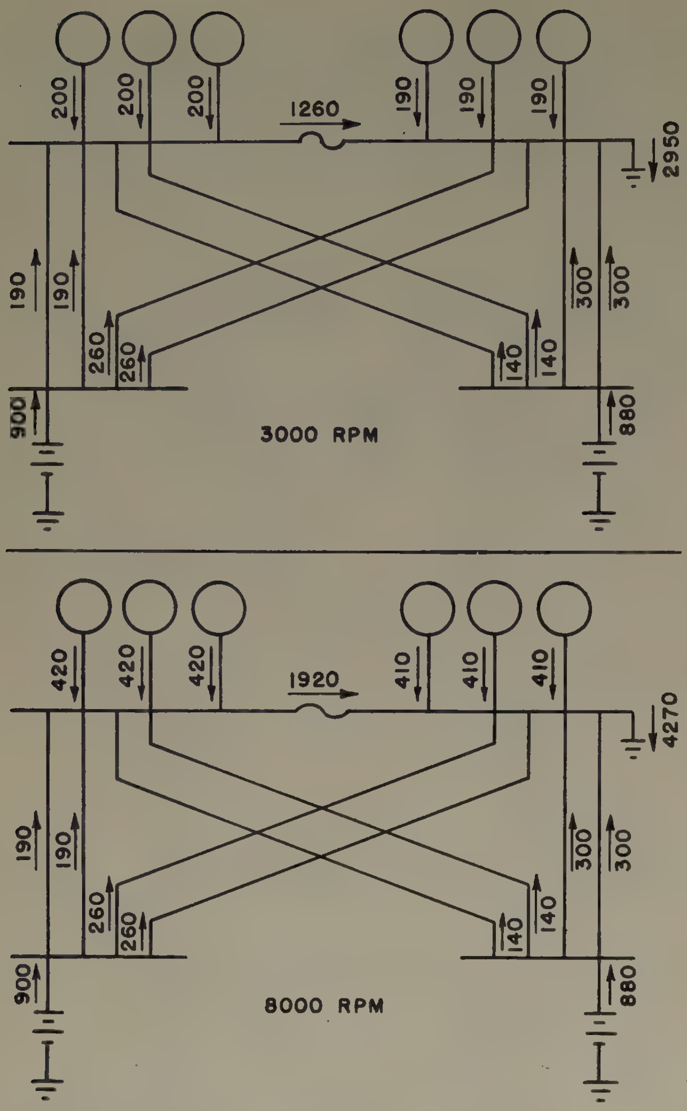


Figure 6. System per unit circuit

A common danger in all these systems is that a faulted bus or bus section will not be isolated from the generators connected to it, possibly resulting in a fire and damage or loss of equipment. The short-circuit current of a genera-



NOTE: ALL CURRENTS GIVEN IN AMPERES

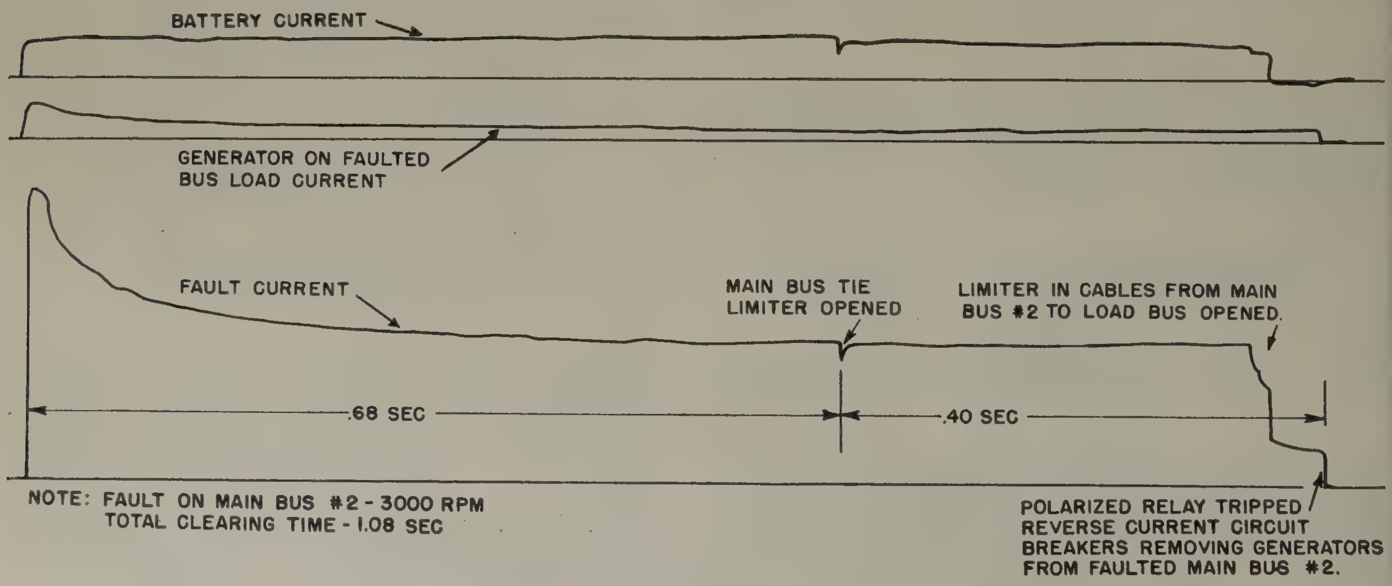
Figure 7. Fault currents for fault on main bus number 2

tor, as shown in Figure 7, may be too small to operate overcurrent protection. Additional devices such as undervoltage or polarized relays connected between bus sections may be used to secure this isolation. A scheme using polarized relays is drawn in Figure 4 for a split-bus system. After the limiters open to isolate bus number 1 from the rest of the distribution system, the flow of current through the polarized relay *A* opens the reverse current circuit breakers of the generators feeding bus number 1 and completes its isolation. A polarized relay appears preferable to an undervoltage relay since it gives faster clearing and there is no problem in co-ordinating relay time delay with system transients or time-current characteristics of overcurrent protective devices.

Use of Battery to Aid in Fault Clearing. For a fault on main bus number 2 of Figure 1, the bus tie limiter opens first. Fault current then flows through the feeders between main busses and load busses.

Without batteries on the load busses, the same current would flow through the limiters protecting main bus number 2 and those protecting main bus number 1. Both sets of limiters would be damaged and either or both sets could clear. With the batteries on the load busses, the feeders to main bus number 2 from the load busses carry more current than do the feeders from main bus number 1 to the load busses. This additional current assures co-ordination between the limiters protecting main bus number 2 and main bus number 1 and results in a minimum loss of system load and generator capacity.

Relation Between Fault Protection and Cable Protection. In the distribution system studied, overcurrent protective devices were chosen in accordance with the methods advocated in this article. Protective devices which are chosen on the basis of load and fault studies are usually smaller than necessary to protect the cable. This is particularly true if the cable size is restricted by having to maintain the proper voltage drop from generator to load bus. If the protective devices were chosen only on cable size, the cable itself could be protected but the system



NOTE: FAULT ON MAIN BUS #2 - 3000 RPM
TOTAL CLEARING TIME - 1.08 SEC

Figure 8. Oscillogram of fault

would not necessarily be fully protected from faults. For example, limiters chosen to protect the feeder cables between main and load busses could be so large that they would fail to open for faults on the main bus. Thus the whole system would be lost and the safety of the airplane jeopardized.

A desired result as stated in the criteria for fault protection is to obtain both protection of the system and all elements of the system. A fault study will determine whether or not the system has the proper co-ordination of protective devices.

Cable Fault Protection by Use of Multiple Cables. The use of multiple cables with limiters at their extremities was found to be an effective means of isolating faulted cables. At the same time, it assures a supply of power to the load even in the case of failure of one of the cables.

System Reliability. One method of increasing the reliability of the system studied would be to protect busses and cables by differential- or balanced-current devices. This method would give faster clearing times and better protection for smaller fault currents than does the present method. On the other hand its use would mean a large number of devices and increased weight, space, and cost.

Since most systems in use today, as well as systems for the near future, rely principally on inverse time overcurrent protective devices for protecting distribution systems, the system chosen for study was of this type. The numerical results obtained apply to this particular system. But the majority of the conclusions are general and apply to aircraft systems which are protected for the most part by inverse time overcurrent protective devices. The study illustrates that evaluation of system reliability for large aircraft requires thorough load and fault studies for the system. Results of such studies point out system deficiencies, suggest ways of remedying these deficiencies, and enable positive conclusions to be drawn regarding system performance and reliability.

CONCLUSIONS

1. A 2-section bus appears to be the best main bus arrangement for ease of fault clearing and general reliability of the system.
2. Symmetrical arrangement of feeders to a load bus from both sections of the main bus results in a better co-ordinated system.
3. For a split-bus system, which employs inverse time overcurrent protective devices, battery location at the load bus permits better co-ordination of those protective devices for main bus faults.
4. Protective devices may be best selected for system protection by using a fault study to determine whether or not these devices are co-ordinated for all fault conditions.
5. System reliability can be evaluated by load and fault studies of the type suggested.

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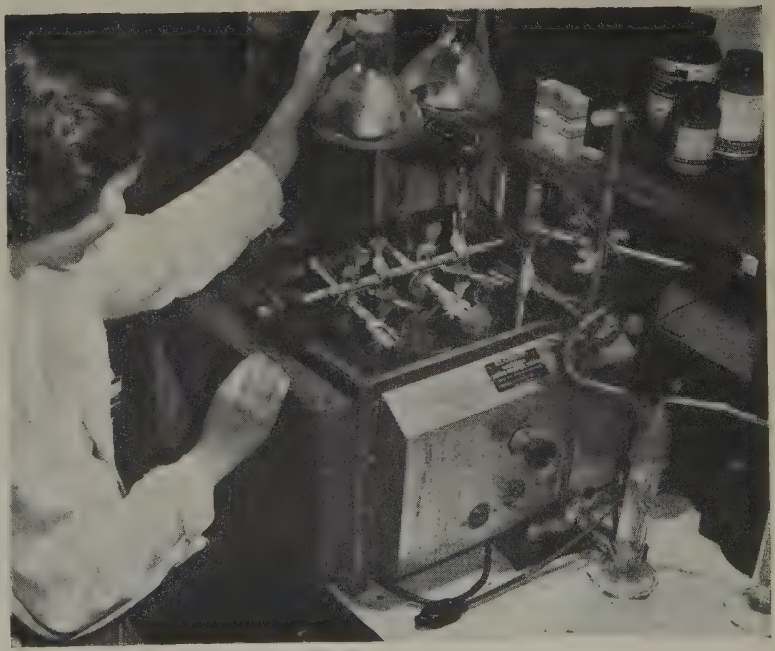
Determining the Rate at Which Human Blood Cells Absorb an Isotope

A technician at the Harvard University Medical School, Boston, Mass., assists in conducting an experiment to determine the rate of entrance of short-lived radioactive sodium into human blood cells. Blood samples containing radiosodium are placed in glass containers. The containers then are submerged under water and agitated by a motor-driven shaker. The water is maintained at a constant temperature identical to that of the human body. At differing intervals samples are removed and "counted" by Geiger counters and electronic equipment to determine the length of time it takes the blood cells to absorb the radiosodium. Such data contribute to fundamental knowledge of red blood cell structure. Because radiosodium loses half its radioactivity within a few hours, the radioisotope is delivered to Boston by special airplane from Brookhaven National Laboratory, Upton, N. Y., where it is produced in the atomic pile.



Bus-Bar Design for High-Frequency Induction Heating

J. W. WILLIAMSON
MEMBER AIEE

This article concentrates on the range of frequencies commonly generated by induction alternators, tabulating current-carrying capacity, resistance, and reactance per unit length for 10,000, 3,000, and 1,000 cycles. However, equations applicable to much higher and lower frequencies are included.

WHERE MOTOR-generator sets are used, induction heating coils are frequently located at points remote from the high-frequency generator in a manufacturing plant. In such cases, one or more transmission lines are required. These may be either of the cable or rectangular bus-bar type. This article deals with rectangular bus bars. Primary attention is given to the range of frequencies commonly generated by inductor alternators. Current-carrying capacity and resistance and reactance per unit length are tabulated for 10,000, 3,000, and 1,000 cycles. Equations are given which apply to much higher and lower frequencies as well. The information supplied has not previously been available to users of induction heating equipment.

RESISTANCE AND REACTANCE

A TYPICAL ARRANGEMENT of rectangular bus bars is shown in Figure 1, with reference to which the combined resistance of the two bus bars and the reactance, both per unit length of run (dimension L) are

$$R_1=\frac{2\rho}{Wd}F \tag{1}$$

$$X_1=\frac{2\rho}{Wd}G+2\pi f\mu_0\frac{S}{W}J \tag{2}$$

where

W = width of either bus bar
S = spacing between bus bars
d = reference depth for conductor material at given frequency
μ_0 = permeability of air or conductor material, expressed in

$$\frac{(\text{Appropriate Lines})/(\text{Unit Area})}{(\text{Unit Current})/(\text{Unit Length})}$$

F and G are functions of the ratio of conductor thickness to reference depth d, and are plotted in Figure 2.
J depends on the ratio S/W of spacing between conductors to width of either conductor and is plotted in Figure 3.
ρ = resistivity of conductor material
f = frequency (cycles per second)

Equations 1 and 2 apply in any consistent units. However, for the remainder of this article it will be assumed that R_1 and X_1 are to be expressed in ohms per inch of run. Then, for copper at 85 degrees centigrade, $=0.85\times10^{-6}$ (ohm-inches). With reference to the definition of μ_0, the meaning of "appropriate" is implied in the statement that a rate of change of one appropriate line per second produces one unit of potential difference in whatever dimension system is used. In the practical system of electrical units, potential differences are expressed in volts. Therefore, for these equations to apply, the appropriate flux line is 10^8 electromagnetic system lines = 1 weber. In the units to be employed

$$\mu_0=3.20\times10^{-8}\frac{\text{webers}/(\text{inch})^2}{\text{ampere}/\text{inch}}$$

and the reference depth d is numerically given by

$$d=3{,}160\sqrt{\rho/f}\ \text{(inches)}$$

Considering copper at a temperature of 85 degrees centigrade,

d = 0.029 inch for a frequency of 10,000 cycles per second
= 0.052 inch for a frequency of 3,000 cycles per second
= 0.092 inch for a frequency of 1,000 cycles per second

To understand equations 1 and 2, first suppose that the reference depth d (which is a measure of how far from the inner faces the current penetrates if the conductors are sufficiently thick) is small in relation to the thickness T. $(W\,d)$, the product of the conductor width and reference depth, may be thought of as the effective area through which current flows in each conductor. Therefore, $\rho/(W\,d)$ is the resistance per unit length for either conductor, and $2\rho/(W\,d)$ the resistance unit length of run.

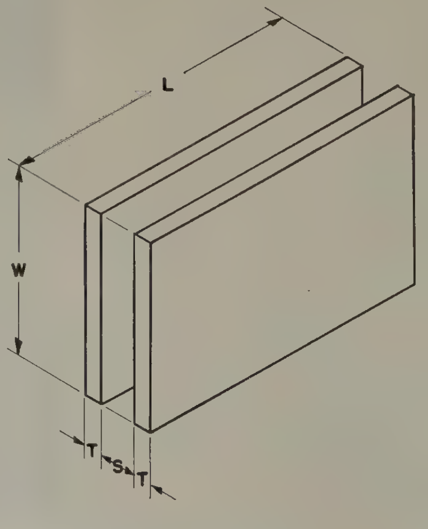


Figure 1. Typical bus-bar arrangement

Full text of paper **52-68**, "Bus-Bar Design for High-Frequency Induction Heating," recommended by the AIEE Committee on Electric Heating and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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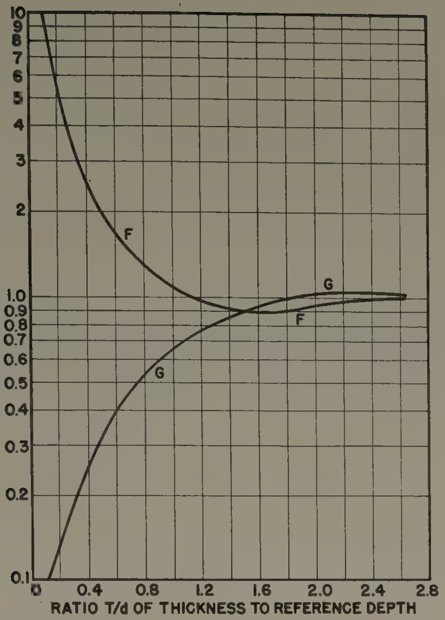
Figure 2. Correction factors F and G



It turns out that $2\rho/(W d)$ is also the reactance per unit length of run, associated with lines of flux within the conductor material. The factors F and G in equations 1 and 2 are practically equal to one, provided the ratio of thickness to reference depth is 1.2 or greater. For copper bus bars, this includes all cases where the thickness is at least 1/8 inch and the frequency is at least 1,000 cycles. For smaller values of T/d, F and G can be obtained from Figure 2.

The second term in equation 2 is the reactance associated with lines of flux in the air space between and external to the two conductors. For close spacings, the reluctance of the flux path in the air space between conductors predominates over the reluctance of the two paralleled paths external to the conductors. Therefore, where I_{inst} is the instantaneous current (amperes) carried by either conductor, the magnetizing force (amperes/inch) between conductors in I_{inst}/W. The magnetic flux density (webers/inch^2) produced by this magnetizing force is $\mu_0 I_{\text{inst}}/W$. Multiplying by the spacing S gives $\mu_0 I_{\text{inst}} S/W$, which is the number of lines of flux (webers) per inch of run. The corresponding components of inductance and reactance per inch of run are, respectively, $\mu_0 S/W$ and $2\pi f \mu_0 S/W$. As the separation is increased, the flux density between conductors becomes less than that which would exist if the reluctance of the air space external to the conductors were negligible in relation to the reluctance of the flux path between conductors, and the correction factor J (Figure 3) is required in the second term of equation 2.[1]

Impedance values calculated from equations 1 and 2 for typical widths, spacings, frequencies of 10,000, 3,000, and 1,000 cycles are given in Table I.

EXPERIMENTAL CHECKING OF FORMULAS

Equations 1 and 2 assume that the current per unit width is constant over the inner faces of the con-

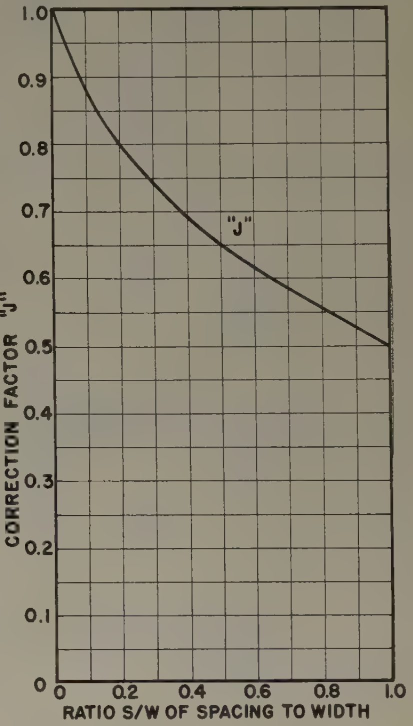


Figure 3. Correction factor J

Table I. Resistance and Reactance Per Unit Length and Current-Carrying Capacity for Copper Bus Bars

Width W Inches	Spacing S Inches	Watts Loss Per Inch of Run for 50 Degrees Centigrade Rise	Frequency								
			10,000 Cycles Micro-ohms Per Inch of Run		Amperes Rated Current	3,000 Cycles Micro-ohms Per Inch of Run		Amperes Rated Current	1,000 Cycles Micro-ohms Per Inch of Run		Amperes Run Current
			R_1	X_1		R_1	X_1		R_1	X_1	
2	0.0625	1.81	29	88	250	16.0	23.8	338	9.2	15.1	444
	0.5	3.45	29	415	345	16.0	132	466	9.2	47.8	613
	0.75	3.67	29	557	355	16.0	174	480	9.2	62.0	631
	1.0	3.67	29	682	355	16.0	211	480	9.2	74.5	631
3	0.0625	2.52	19.5	60	360	10.7	22.7	487	6.2	10.2	639
	0.5	4.88	19.5	294	500	10.7	93	676	6.2	33.6	888
	0.75	5.48	19.5	406	530	10.7	127	716	6.2	45.0	941
	1.0	5.58	19.5	501	535	10.7	155	723	6.2	54.0	950
4	0.0625	3.44	14.6	45	485	8.0	17.2	655	4.6	7.7	861
	0.5	5.72	14.6	229	625	8.0	72	844	4.6	26.0	1,110
	0.75	6.85	14.6	319	685	8.0	99	925	4.6	35.0	1,220
	1.0	7.37	14.6	401	710	8.0	124	960	4.6	43.0	1,260
6	0.0625	4.42	9.7	37.5	675	5.3	13.6	913	3.1	5.9	1,200
	0.5	6.82	9.7	159	840	5.3	50	1,130	3.1	18.0	1,490
	0.75	7.70	9.7	224	890	5.3	70	1,200	3.1	24.5	1,580
	1.0	9.30	9.7	284	980	5.3	88	1,320	3.1	30.5	1,740
	1.5	10.6	9.7	396	1,045	5.3	122	1,410	3.1	41.7	1,860
8	0.0625	5.41	7.3	22.9	860	4.0	8.7	1,160	2.3	3.9	1,530
	0.5	8.20	7.3	121	1,060	4.0	38.2	1,430	2.3	13.7	1,880
	0.75	9.59	7.3	172	1,145	4.0	54	1,550	2.3	18.8	2,040
	1.0	10.7	7.3	221	1,210	4.0	68	1,630	2.3	23.7	2,150
	1.5	13.1	7.3	311	1,340	4.0	95	1,810	2.3	32.7	2,380
	2.0	13.5	7.3	393	1,360	4.0	120	1,840	2.3	40.9	2,420

Note: All values apply if the thickness T is at least equal to 1/8 inch. Resistance and reactance values apply and the remaining values very nearly apply if the thickness T is at least 0.035 inch for 10,000 cycles, 0.064 inch for 3,000 cycles, and 0.111 inch for 1,000 cycles.

Table II. Comparison Between Calculated and Measured Resistance and Reactance Per Unit Length for Frequency of 10,000 Cycles

Width W Inches	Thickness T Inches	Spacing S Inches	Micro-ohms Per Inch of Run			
			Calculated Resistance	Calculated Reactance	Measured Resistance	Measured Reactance
2	0.0625	0.064	29.2	90.3	28.2	89.4
		0.128	29.2	146	29.2	148
		0.256	29.2	248	29.2	230
		0.510	29.2	421	28.2	386
		1.00	29.2	682	30.2	612
		1.97	29.2	1,022	30.5	924
2	0.25	0.064	29.2	90.3	28.8	89.4
		0.510	29.2	421	27.8	371
		1.00	29.2	682	26.0	587
		1.97	29.2	1,022	26.0	891
4	0.25	0.255	14.6	131		127
		0.510	14.6	233	15.5	216
		1.00	14.6	401	15.0	366
		2.00	14.6	669		608

Note: Experimental values are corrected to temperature of 85 degrees centigrade, so as to be comparable with calculated values.

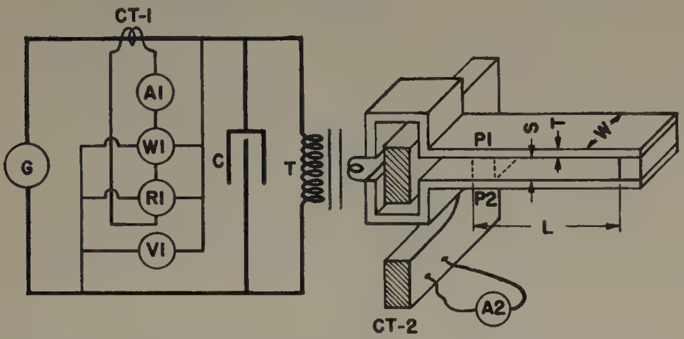


Figure 4. Experimental arrangement used to determine impedance and current-carrying capacity

ductors. To test the effect of this and other assumptions, the experimental arrangement shown in Figure 4 was used, and 10,000-cycle power was supplied by a rotating generator *G*. This power was metered through ammeter *A1*, wattmeter *W1*, varmeter *R1*, and voltmeter *V1*. The capacitor *C* was adjusted for approximately unity power factor at these meters, to obtain accurate power readings. A standard type of induction heating transformer *T* was used to step down voltage and increase current. The bus bars being tested were connected to the "fishtails" of this transformer and spread out near these "fishtails" to permit the insertion of a current transformer, *CT2*. The impedance over the run *L* was found by dividing the voltage between points *P1-P2* by the current metered through current transformer *CT2*. To determine losses over the length *L*, two readings were taken through wattmeter *W1*, both with the same bus-bar current. One of these readings was taken with this current flowing over this entire length. The other reading was taken with a jumper inserted at *P1-P2*. Subtracting and correcting for differences in capacitor and transformer losses gave the watts loss over length *L*. Dividing this loss by the current squared gave the resistance. Having found the impedance, the reactance could then be determined. In most cases the reactance is practically equal to the impedance. The length *L* was 24 inches in all cases.

Table II gives a comparison between experimental and calculated impedance values for several spacings of 2- and 4-inch wide bus bars. The frequency was 10,000 cycles. For close spacings, equations 1 and 2 give accurate results, as might be expected since here the current per unit width should be constant over the inner faces of the two conductors. If the spacing is increased, the current per unit width along the inner faces becomes less uniform, and there is some current along the side faces or edges. For 1/16-inch thick bus bars the effect of current carried by the edges is minor, and the resistance per unit length increases with increased spacing, due to uneven current distribution on the inner faces. For 1/4-inch thick bus bars sufficient additional current is carried by the edges with increased spacings so that the resistance per unit length decreases. High-frequency currents tend to distribute themselves along the surfaces of the conductors carrying them in such a way as to minimize reactance. Therefore, where the spacing is appreciable and the current density is not uniform over the inner faces and zero elsewhere, as assumed in calculations, the actual reactances are less than the calculated values. The reduced accuracy of equations 1 and 2 when the spacing is more than about one-fourth the width is not a serious limitation on their usefulness. As will be described, large spacings do not increase current-carrying capacity, and in general would be used only where necessary to avoid danger of voltage breakdown.

CURRENT-CARRYING CAPACITY

THE CURRENT WHICH a transmission line can carry is here taken as that which results in a temperature rise of 50 degrees centigrade above a 35 degree centigrade ambient. The amount of power per unit length which a pair of rectangular bus bars can dissipate in still air with a given temperature rise depends on:

1. The spacing.
2. Whether the dimension *L*, Figure 1, is horizontal or vertical.
3. If *L* is horizontal, whether *W* is horizontal or vertical.

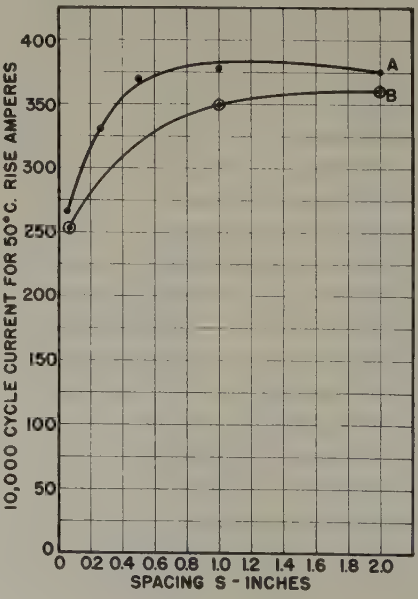


Figure 5. Current-carrying capacity for two 2-inch wide, 1/4-inch thick copper bus bars on 10,000 cycles

A—2-inch dimension (W) vertical

B—2-inch dimension (W) horizontal

4. The color of the surface (which determines how much heat can be dissipated per unit time by radiation).

All tests to determine current-carrying capacities were made with L horizontal, this being the case of principal interest. Figure 5 gives a comparison between the experimentally determined current-carrying capacity of 2-inch wide, 1/4-inch thick copper bus bars with W horizontal and W vertical, the frequency being 10,000 cycles. The current-carrying capacity is greatest with W vertical, since in this position of the bus bars the air in the space between them is allowed to rise when heated, thus increasing the absorption of heat by convection This effect is most pronounced if the spacing is equal to one-fourth the width, where the current-carrying capacity with W vertical is about 15 per cent greater than with W horizontal.

Figure 6 shows current-carrying capacity per unit width plotted against the ratio of spacing to width for 2- and 4-inch wide bus bars. It is seen that if the width and spacing are both doubled, the current-carrying capacity is approximately doubled also.

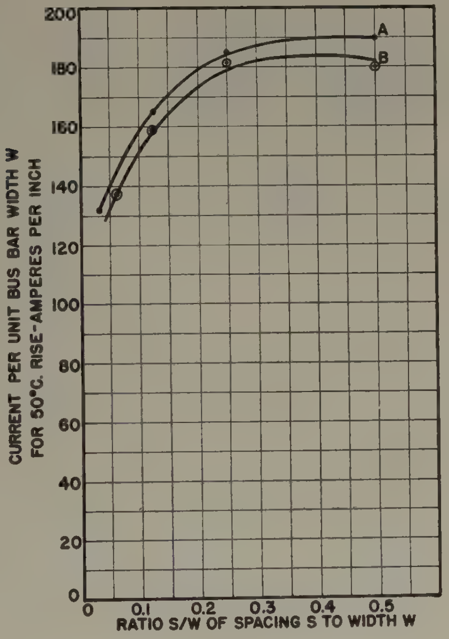


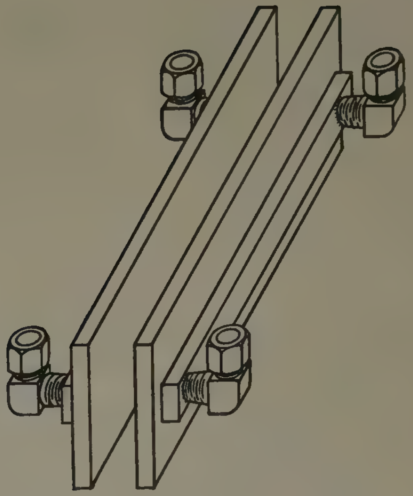
Figure 6. Current-carrying capacity per unit width for 1/4-inch thick copper bus bars on 10,000 cycles

A—2-inch wide bus bars
B—4-inch wide bus bars

For a given transmission line which may be operated at two different frequencies, the product of the allowable current squared multiplied by the resistance per unit length is the same for both frequencies. This fact was used in Table I for extending experimentally determined current capacities for a frequency of 10,000 cycles to other frequencies. The current-carrying capacities given also may be compared with those for 60 cycles, on the basis that the watts per inch of run for a 50-degree-centigrade rise should be the same for all frequencies.

Current-carrying capacity values in Table I are for copper bus bars, carrying a current in the horizontal direction with dimension W vertical. The color of the surface is taken as that of oxidized copper. If the surface is coated with black oxide of lead, the current-carrying capacities are increased due to increased radiation. If the spacing is one-fourth the width, the allowable current is 12 per cent greater with a black oxide of lead surface than with an oxidized copper surface.

Figure 7. Water-cooled bus bars



When a large current must be carried within a limited space, it may be necessary to use water-cooled copper bus bars. A typical construction is shown in Figure 7.

CONCLUSIONS

1. Equations have been presented for the calculation of resistance and reactance per unit length of rectangular bus-bar transmission lines. These equations have been checked experimentally for a frequency of 10,000 cycles.

2. Values of current-carrying capacity have been determined experimentally for certain combinations of width and spacing at 10,000 cycles and extended to other combinations of width, spacing, and frequencies.

3. For convenience, the results of equations 1 and 2 have been tabulated for frequencies of 10,000, 3,000, and 1,000 cycles.

4. If the thickness T is greater than 1.2 d, where d is the reference depth, the resistance per unit length is not appreciably decreased.

5. Maximum current-carrying capacity with a given size bus results when the width W is vertical, the spacing S is at least equal to 0.25 W, and a coating of black oxide of lead is applied to increase radiation. If additional current-carrying capacity is required, a larger bus or water cooling is required. There is no advantage to a spacing S greater than 0.25 W with W vertical, except where reactance is required for matching or there is danger of a voltage breakdown. Unless a strip of insulation is provided between the bus bars, the spacing should be not less than 1/2 inch for an rms potential difference of 440 volts, or 220 volts and 3/4 inch for an rms potential difference of 800 volts to avoid the possibility of a voltage breakdown.

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Power System Stability Criteria for Design

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The data presented here are based on a study of the relative power limit for different types and locations of faults on an initial system that could be represented by two or three machines, and a further series of studies of the relative effect of type of fault, location of fault, speed of clearing and reclosing the faulted line, and the direction of power flow in the interconnecting tie circuit.

THE POWER SYSTEM DESIGNER is often confronted with the problem of what criterion for stability to use as a basis for design. If the system is to be designed on the basis of circuit power flows below the transient stability power limit, the questions arise: Should 3-phase, 2-line-to-ground, 2-line, or 1-line-to-ground faults be used? Should the fault be located on the line right at the bus? How fast should the fault be cleared? Should fast reclosing be used, and if so, how fast? How much will reduced plant reactance or a switching station improve the stability limit?

In most of the studies of the Bureau of Reclamation power systems in the 17 western states, time does not permit evaluation of the foregoing factors on the basis of the relative power limit for each case. The Bureau's systems now have installed capacity of about 3,939,500 kw in generation and 6,770 miles of transmission lines. Any engineer who has participated in a-c network analyzer studies knows how laborious the job of determining the power limit can be, when as many as 12 generators are involved in each power-swing calculation. As our a-c network analyzer has been in almost continuous use on specific power system design, planning, and operating problems since it was installed in October 1948, usually we have time only to determine whether a given power system is stable or unstable for a specified loading condition, and to make the system stable if that particular loading condition is critical. Thus, when we did have an opportunity to study the relative power limit for different types and locations of faults on an initial system that could be represented by two or three machines, it was felt that the results of the study might be of interest to other power system engineers.

As the results of these studies are intended for power system design engineers, the power plants and other locations are referred to as *A*, *B*, *C*, *D*, *E*, and *F*. In this way, although the studies were for the initial stages of a specific future system to be built, it will not be necessary to describe the plans for the various stages of development of this power system. Figure 1 shows an impedance diagram of the system studied.

EFFECT OF SWITCHING STATION

FIGURE 2*a* is a simplified representation of the system with the generating plant of 400 megawatts capacity at *A* supplying a load of 150 megawatts at *B* and *F* over one separate 230-kv circuit, and interconnected over another separate circuit to the composite system of generation and loads represented at *C*. When a 3-phase fault is applied to the separate circuit supplying the 150-megawatt load, the stability limit of the interconnecting tie line *A-B-C* is 80 megawatts and 115 megawatts, respectively, for two values of plant reactance at *A*. It was assumed that the fault will be cleared in $4^1/_2$ cycles and the circuit re-energized in 20 cycles.

Figure 2*b* shows the effect of a switching station on the two 230-kv circuits at a point 65 miles away from power plant *A*. With a 3-phase fault at the same location and on the same circuit, cleared and reclosed with the same speeds as in Figure 2*a*, the stability limit of the interconnecting circuit *B-C* is now 118 megawatts and 132 megawatts, respectively, for the corresponding impedances of Figure 2*a*. The switching station has increased the stability power limit of the single interconnecting circuit by about 48 per cent for the higher plant reactance, and about 15 per cent for the lower plant reactance. This proves the advantage of intermediate switching stations in general, and shows that this advantage is most effective where the system has high impedances.

Figure 2*b* also shows the stability limit of the 65-mile section of the two circuits between the power plant, *A*, and the switching station at *B* to be increased to 275 megawatts and 290 megawatts, respectively, for the two plant reactances. This is an increase over the total power stability limit for the separate lines totaled together, as well as eliminating even a 20-cycle interruption in service to customers at *B* or *F*. In addition, either of the two circuits between *A* and *B* may be taken out of service for maintenance purposes without interruption of service to customers at *B* or *F*, or to the interconnection between

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The author wishes to acknowledge the assistance of his associates, in particular Harvey Hunkins of the Power System Technical Section of the Bureau of Reclamation, and H. B. Palmer, University of Colorado, Boulder, Colo., for their work in developing ways of expediting the network analyzer studies and calculations.

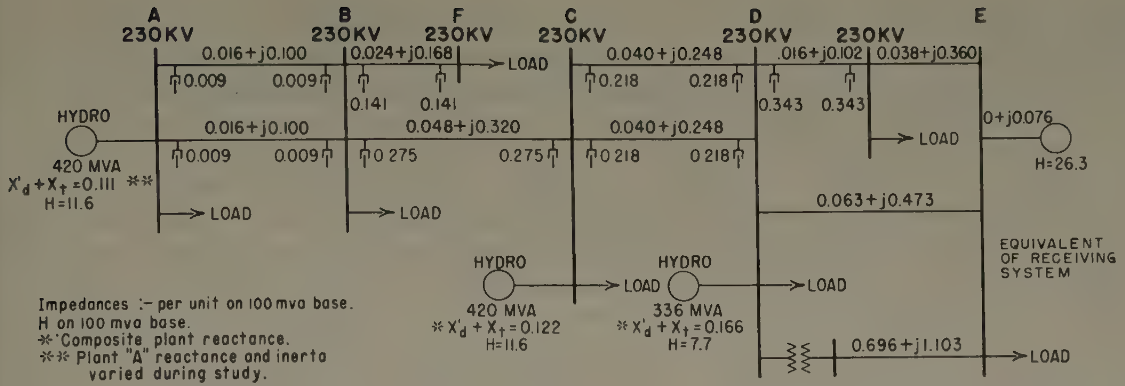


Figure 1. Detailed impedance diagram of the power system studied

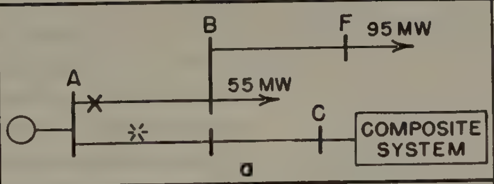
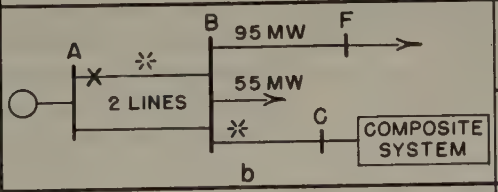
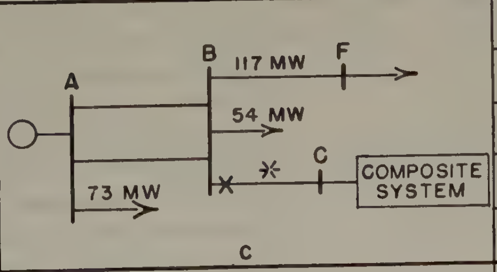
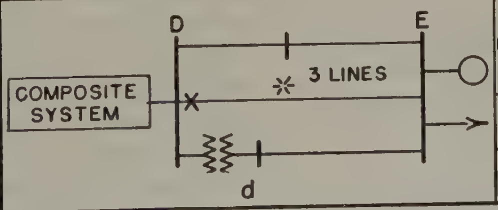
B and the composite system at *C*. Thus, there is little question as to the value of the switching station at *B* to the stability power limit of the interconnection tie line between *B* and *C*, and to the flexibility and reliability of the two circuits between *A* and *B*.

EFFECT OF LOWERING PLANT REACTANCE

FIGURE 2*c* SHOWS the effect of lowering the plant reactance at *A*, and of fast reclosing of circuit breakers upon the stability power limit of the interconnecting tie line between *B* and *C*. The inertia of the generators at plant *A* was varied to match the corresponding value of generator transient reactance during the stability power swing calculations. Reduction of the over-all plant reactance at *A* from 0.146 per unit on a 100-megavolt-ampere base to 0.106 per unit, or about 27 per cent, results in an increase in the power limit of the interconnection tie line of about 85 per cent for 20-cycle reclosing, and about 59 per cent for 12-cycle reclosing. It is seen that a reasonable reduction in plant reactance at power plant *A* is justified.

20- VERSUS 12-CYCLE CIRCUIT BREAKER RECLOSING

THE ADVANTAGE OF fast reclosing is illustrated in Figure 2*c*. For the same plant reactance, it is seen that the use of 12-cycle reclosing instead of 20-cycle reclosing would increase the stability limit by 88 per cent for the higher plant reactance, and 62 per cent for the lower plant reactance. In the locality in which this system is to be built the isoceraunic level is quite high so that, even with overhead ground wires on the transmission lines, it is expected that there will be a considerably larger proportion of faults due to lightning than to other causes. Therefore, fast circuit breaker reclosing is advantageous in that it will maintain a certain power stability limit for the interconnecting tie line between *B* and *C* for most faults, whereas, without fast reclosing, every fault would

SCHEMATIC DIAGRAMS SHOWING LINE SECTION STUDIED	PLANT A REACTANCE PER UNIT	CLEARING TIME	RECLOSING TIME	POWER LIMT	
		CYCLES	CYCLES	LINE SECTION	MW
	.146	$4\frac{1}{2}$	20	A–C	80
	.106	$4\frac{1}{2}$	20	A–C	115
	.146	$4\frac{1}{2}$	20	B–C	118
				A–B	275
	.106	$4\frac{1}{2}$	20	B–C	132
				A–B	290
	.146	$4\frac{1}{2}$	20	B–C	35
	.137	$4\frac{1}{2}$	20	B–C	40
	.106	$4\frac{1}{2}$	20	B–C	65
	.146	$4\frac{1}{2}$	12	B–C	66
	.106	$4\frac{1}{2}$	12	B–C	105
	PLANT D REACTANCE PER UNIT				
	.182	$4\frac{1}{2}$	20	D–E	238
	.155	$4\frac{1}{2}$	20	D–E	243

Refer to Figure No. 1 for details of system arrangement.
All cases are for power transfer from left to right.
* Indicates lines for which transient power limits were obtained.
X Indicates location of 3 phase faults.

Figure 2. Summary of initial stability power limit studies

a—Without switching station at B
b—With switching station at B
c—Effect of plant reactance at A and reclosing times
d—Effect of plant reactance at D

mean an interruption of service. Also, if experience demonstrates that reclosing of circuit breakers in a time of about 12 cycles is practical considering the possibility of the deionized fault arc gasses not being fully dissipated in that short time, 12-cycle reclosing, or at least reclosing faster than 20 cycles, would increase the power limit of this interconnecting tie line considerably over that of 20 cycles and would be desirable.

LOADING ASSUMPTIONS FOR THE TWO STUDIES

In the foregoing study, it was the purpose to compare the effects of the following: (*a*) with and without a switching station at *B;* (*b*) the effect of power plant reactance at *A* on the stability limit of the interconnecting tie line between *B* and *C;* and (*c*) the increase in stability power limit on this same tie line when the reclosing circuit breaker time is reduced from 20 cycles to 12 cycles. To obtain this comparison in the simplest manner on the a-c network analyzer, 3-phase faults cleared by both terminals in $4^1/_2$ cycles by carrier-current relaying was assumed with the faults located on the line immediately at the bus. System loads were held essentially constant, and power output was shifted between plant *A* and plants at *C* and *D* with all generators in each plant connected to the system so as not to change the impedance or inertia of the system. For most cases, this resulted in plant *A* operating below nameplate rating.

When time permitted at a later date, a second series of studies were made to determine the relative effect of type of fault, location of fault, speed of clearing and reclosing the faulted line, and the direction of power flow in the interconnecting tie circuit. These more complete studies differed from the initial studies in that loads were varied in the two areas to change the power transfer across the tie circuit *B-C* with generation at all plants held constant at full rated output. This more nearly represented the condition for meeting peak loads by transfer of power across the tie line, and resulted in lower power limits for transient stability than were obtained in the first series of studies. The plant reactance and inertia used at *A* during these studies are the values indicated in Figure 1.

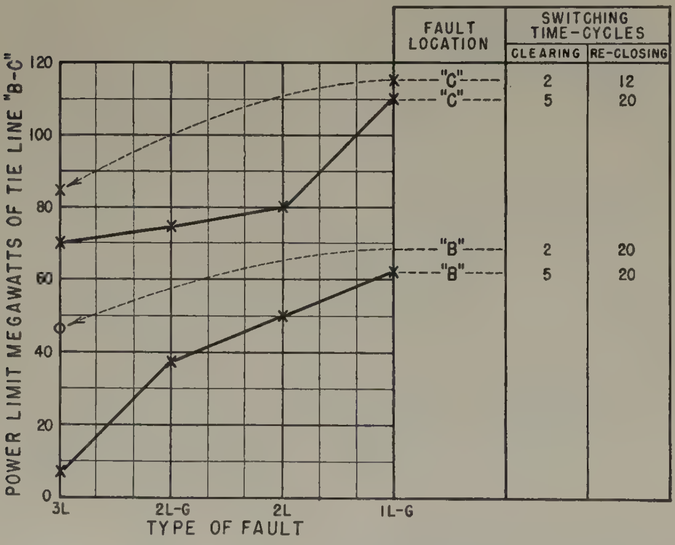


Figure 3. Effect of type of fault, fault location, fault clearing, and line reclosing times with direction of power flow from the low-inertia system, B, to the high-inertia system, C

SENDING GENERATOR INERTIA AND LOADING

Figures 3 and 4 show the power limit of the tieline *B-C* for various types of faults and fault locations on the circuit *B-C*, different times of clearing, and reclosing the circuit breakers, for direction of power flow from *B* to *C*, and from *C* to *B*, respectively. It is seen that the power limit is roughly less than 1/3 as much for power flow from *B* to *C*, that is, from the low-inertia system to the high-inertia system than for the reverse direction. The combined inertia of rotating machines at *C*, *D*, and *E* is about four times as great as at plant *A*, which has an $H=11.6$. This illustrates the difficulty of maintaining stability between a remote power plant connected to a large system by a single transmission line.

A comparison of power limits for a 3-phase fault at *B* for the conditions of Figure 2*c* and Figure 3 illustrates the effect of generator loading on the stability of the system. As explained previously, for both figures the total plant generation or inertia was connected to the system, that is, the equivalent of 400 megawatts. However, for Figure 2*c*, it may be seen that the load on the generators at plant *A* amounts to from 279 to 309 megawatts, depending upon the plant reactance, whereas the load on the generators at plant *A* for Figure 3 amounts to 400 megawatts. In Figure 2*c*, for a plant reactance of 0.137, the power limit is 40 megawatts. This is more than 4 times as great with the generators about 3/4 loaded, as compared with Figure 3. Here a power limit of less than 10 megawatts is obtained with the generators fully loaded even with a lower plant reactance of 0.111. There probably is no direct relationship between the stability limit of the line and the generator loading as it would depend upon many factors, but the important thing is that generator loading has an important effect on system stability.

EFFECT OF TYPE AND LOCATION OF FAULT

The variation in power limit of the tie line *B-C*, as influenced by the type and location of fault, is illustrated in Figures 3 and 4. The effect of the type of fault is closely related to its location. This is due to the differences in relative impedances of the zero sequence network, where ground faults are concerned, as compared to the positive sequence network. In both figures, it is seen that the 3-phase fault is most severe when applied at the sending end.

The maximum difference in power limit between the worst 3-phase type and the lightest 1-line-to-ground type is only about 7 per cent as shown for faults at *C* with 5–20-cycle clearing and reclosing on Figure 4. For faster fault clearing and reclosing, this difference is less than 5 per cent. For practical purposes, the type of fault is immaterial when considering power flow from a system of large inertia to one of low inertia.

The type of fault and its location has the greatest effect when the direction of power flow is from the system of low inertia to the system of high inertia as illustrated in Figure 3. The type of fault at the sending end at *B* in Figure 3 makes a difference of over six times in the power limit. It would appear that 2-line-to-ground and 2-line faults would represent an average type of fault as far as effect on the system is concerned. In Figure 3, the average type of fault at *C*, the receiving end of the tie line, has a power limit approximately twice that of the stability power limit due to the average type of fault when located at the sending end, *B*.

EFFECT OF FAULT CLEARING TIMES

It was pointed out previously in the discussion of Figure 2*c* that the stability power limit would be increased by increasing the speed of circuit breaker reclosing from 20 cycles to 12 cycles. Other effects of both fast fault clearing and reclosing are illustrated in Figures 3 and 4. Figure 3 shows that faster fault clearing and reclosing has about 10-per-cent improvement on the stability power limit for faults at *C*, the receiving end. However, Figure 3 also shows that, with 20-cycle reclosing in both cases, the power limit for a 3-phase fault at *B*, the sending end, would be increased about five times, by reducing the fault clearing time from 5 cycles to 2 cycles. The 230-kv oil circuit breakers have been improved considerably in the last 20 years, and tests show that the present 3-cycle circuit breakers can clear faults in about 2 cycles. Thus, considering the possible use of fast transferred tripping by microwave channels, 2-cycle clearing of faults may be a realistic figure to use for some systems in anticipation of further improvements in equipment.

In Figure 4, with power flow from the large inertia system toward the smaller inertia system, the improvement in stability power limit, with the faster clearing and reclosing times, is about 40 or 50 per cent for average type and location of fault. Further, it is seen that there is scarcely any difference in the effect of the type of fault for a given fault location with 2-cycle clearing and 12-cycle reclosing. In addition, the location of the fault on the tie line between sending and receiving ends makes a difference of less than 10 per cent for the average type of fault. Thus, the location of the fault becomes less important as faster circuit breaker clearing and reclosing times become available.

IMPROVEMENT IN STABILITY NOT ALWAYS JUSTIFIED

Lest the reader receive the impression that transient stability studies on an a-c network analyzer always prove that the power system needs a switching station, reduced transient reactance at an additional cost, faster circuit breaker operation, and so forth, refer to Figure 2*d*. Here it was proved that the stability limit for a fault at *D* was already quite high because there were two 230-kv circuits and a 115-kv circuit between points *D* and *E*, the equivalent system. A 3-phase fault, cleared in $4^1/_2$ cycles and circuit reclosed in 20 cycles, had a stability limit of about 240 megawatts, and there was only about a 5-megawatt improvement with substantial reduction in generator transient reactance at plant *D*. Thus it is seen that this study proved that there would be insufficient justification for reducing the generator transient reactance at plant *D*. The location of plant *D* in the system is such as to make it much less of a stability problem than plant *A* which is relatively isolated.

EVALUATION OF STABILITY IMPROVEMENT

It is possible to evaluate the improvement in the power system stability limit in a number of ways depending upon the particular system. A few of the factors to be considered, where stability improvement is obtained by reduced generator and transformer reactance, are as follows:

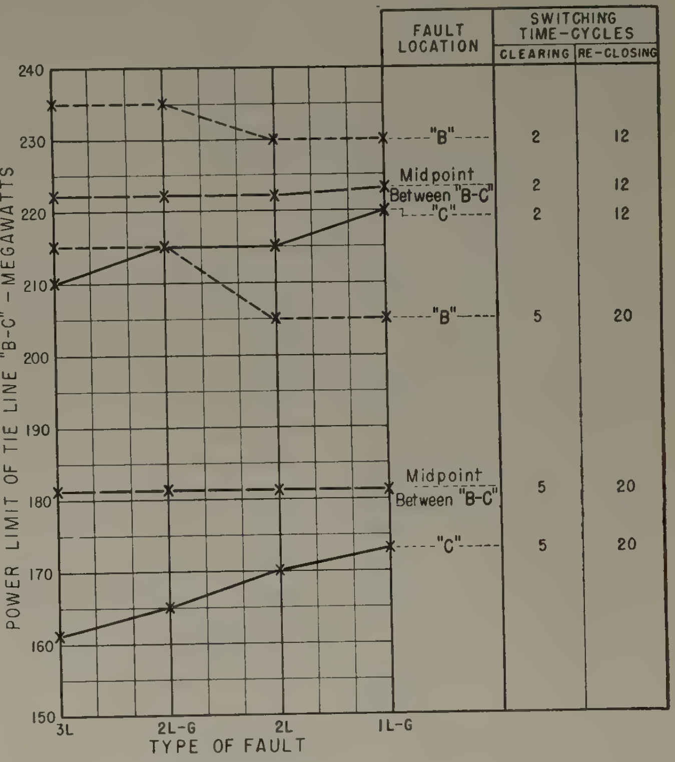


Figure 4. Same conditions as for Figure 3 except direction of power flow from the high-inertia system, C, to the low-inertia system B

1. The increased revenue resulting from transmission of more energy over the system and the increase in peaking capability.
2. The cost of additional generating capacity at the load end of the system equivalent to the increase in system stability limit.
3. The cost of additional system facilities, such as transmission lines, sectionalizing stations, carrier relaying, high-speed tripping, and reclosure of circuit breakers, and so forth, required to produce an equivalent increase in stability limit.
4. The unit cost of the entire power system; that is, the cost of the total capital investment divided by the total installed generating capacity.

Figure 5 shows a method of relating the cost of reducing the plant reactance to stability limit. Although the

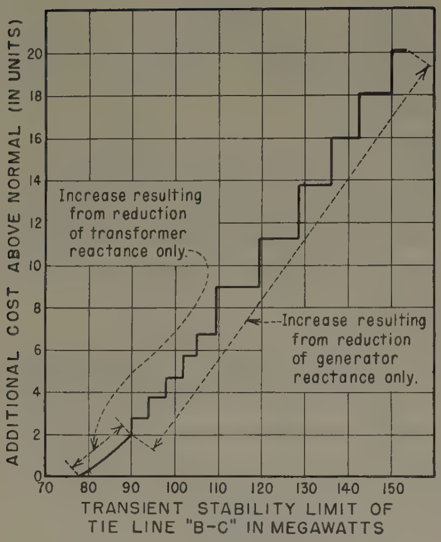


Figure 5. Increase in cost of equipment at power plant A versus the stability limit of the single 230-kv tie line, B-C

actual cost in dollars is not indicated, the stepped portion of the curve corresponds to the bracketed price increases on the generators and transformers for stepped reductions in transient reactance. The method of converting the stability limit into benefit dollars to compare with the cost dollars will depend upon the individual system, as indicated.

The load area supplied by power plant *A* probably will be such as to allow little power normally to flow over the tie line *B-C* to or from the load area supplied by power plants at *C* and *D*. However, variable water supply for power generating purposes at either of the three power plants for any of a number of reasons would cause the tie line to carry power in either direction; and, if loads develop in a different manner than estimated, the power flow could be mostly in one direction. Instead of constructing a second 230-kv circuit between *B* and *C* at a cost of millions of dollars, it appears that adequate power limit and capability on this tie circuit will be obtained by reduced plant reactance at *A* and fast reclosing of circuit breakers costing only thousands of dollars, considering that *B-C* is a tie circuit and not a main supply circuit.

CONCLUSIONS

THIS ARTICLE HAS SUBSTANTIATED many theoretical discussions and analyses with a specific example. Some of the conclusions that may be made from this particular study are as follows:

1. The type of fault and its location on the line have little effect on the stability power limit of a line when power flow is from a system with large inertia to one of small inertia. With the availability of faster relaying and circuit breaker times, it appears that stability studies could use a 3-phase fault as the criterion for design with little fear that it would be too conservative.

2. When studying the case of a relatively small inertia plant supplying power to a large inertia system, greater care must be given to the assumptions to be used in determining the stability power limit. Attention should be given to the loading assumed on the generators prior to the stability condition, as well as to fault type and location, time of clearing and reclosing, and so forth.

3. Fast reclosing of circuit breakers in a time of about 20 cycles will give a stability power limit on a single tie circuit, where otherwise there would be an interruption to service for all faults due to lightning. The power limit may be increased by reducing the reclosing times below 20 cycles, with the lower limit determined by experience in the time it takes the deionized fault arc gasses to dissipate adequately.

4. The manufacturers should be urged to continue to improve circuit breaker opening times and the speed of relaying equipment because the speed of clearing faults has an important effect on the transient stability power limit of power systems.

REFERENCES

1. Analysis of the Application of High-Speed Reclosing Breakers to Transmission Lines, **S. B. Crary, L. F. Kennedy, C. A. Woodrow.** *Electrical Engineering* (AIEE *Transactions*), volume 61, 1942, pages 339–48.

2. Reclosing of Single Tie Lines Between Systems, **W. W. Parker, H. A. Travers.** *Electrical Engineering* (AIEE *Transactions*), volume 63, 1944, pages 119–22.

Electromagnetic Pump Moves Molten Metals at High Temperatures

A new a-c electromagnetic pump with no moving parts, for pumping liquid metals and other low-resistance conducting fluids at temperatures up to 1,000 degrees Fahrenheit, has been developed by the General Electric Company.

The new pump can be used to move any conducting fluid that has a specific resistance equal to or less than stainless steel. Liquid metals such as sodium, sodium-potassium alloys, and lithium fit this classification.

The pump operates on the principle that a current-carrying conductor in a magnetic field is acted on by a force. In this case, the fluid serves as the conductor, so that when current and flux are properly applied, pumping occurs.

One of the three basic elements of the pump, a transformer unit, sets up a high current through the liquid metal and, simultaneously, a magnetic field perpendicular to that current. A cell unit, which consists of a flattened stainless-steel pipe, carries the liquid metal through the magnetic field. The third basic part, a capacitor unit, provides power factor correction.

The amount of liquid metal which can be pumped in a given period varies with the pressure. At 20 pounds per square inch the pump is able to move approximately 28 gallons of molten metal per minute.

The transformer unit of the new electromagnetic pump is 19 by 13 by 12 inches, the capacitor unit is 22 by 15 by 10 inches, and the cell is 1-inch standard pipe of number 347 stainless steel, 10 inches long. The equipment operates on 230 volts at 30 amperes. An adjustable autotransformer with fuse and switch is required.

The Notched-Disk Memory

JACOB RABINOW

The notched-disk memory appears to be a very significant development in electromechanical information storage techniques. Its possible applications are manifold, including such diversified automatic information processing activities as electronic computing, telephone switching, ticket reservations, optical recording, and business accounting.

As the operations of government and private business become more varied in nature and larger in scope, the problem of adequate record keeping is continually becoming more acute. Not only is the volume of records rising to unprecedented magnitude, but also the time required to store and later reach this information is becoming continually of greater importance. There is little reason to doubt that modern advances in electronics will greatly modify the handling of information in large enterprises, both governmental and private. In all systems of automatic handling of information, one of the key elements is the device for storing information.

A magnetic information-storage device now being developed at the National Bureau of Standards (NBS) combines advantages of large storage capacity and rapid access time. The new "memory" stores data in the form of magnetic pulses on both sides of thin metal disks, which are mounted in a doughnut-shaped ring with the planes of the disks vertical. Each disk has a deep notch, and the notches are normally aligned so that a bank of magnetic recording-reading heads can be quickly rotated into position at any desired disk. Test results demonstrate that stored data can be reached in times of the order of 0.5 second. This memory was devised at NBS by request of the Ballistic Research Laboratory of Aberdeen Proving Ground, Md. Two models are nearing completion.

It has long been recognized that 3-dimensional storage of information, as in a book, utilizes space most efficiently. Previous 3-dimensional storage systems, however, have had the disadvantage of relatively long access time. The usual method of storing information in three dimensions has been to record it on a film strip, or on magnetic wire or tape. The difficulty is that the whole reel may have to be played in order to reach a particular bit of data; thus while the storage is 3-dimensional, the playback is either 1- or 2-dimensional, and is sequential. Short bits of magnetic wire can be used to reduce access time, but then the amount of machinery required becomes very large.

THE NOTCHED DISKS

The storage of information on magnetically coated disks appeared to be attractive from several points of view when the problem was approached at NBS, but the known methods of selecting and playing each disk did not seem promising. Disk-record changing mechanisms are old, and disks can be selected and played in many ways, but if a machine is to have as many as several thousand disks old mechanisms are inadequate, particularly from the standpoint of rapid access.

The solution arrived at was a design in which a deep notch extends most of the way to the center of each disk. The disks are arranged on a common shaft, and the notches are aligned so as to permit the magnetic heads that are to scan the disks to pass through the channel formed by the notches. This makes it possible to move the heads rapidly to the desired disk.

It soon became apparent that a more effective arrangement of the disks is to mount them on a circular shaft in the form of a toroid or "doughnut." The magnetic heads then can be rotated on a central shaft instead of being moved in a straight line. This design, which results in a simple and rugged machine, was therefore adopted.

When the heads are in position, the disk is rotated past them while information, in the form of coded magnetic pulses, is recorded or read out. A large number of heads, spaced along a radius of the disk, are used so that the whole useful area of each disk can be read or written upon in a single revolution of the disk. The bank of heads is divided into two halves, with a narrow slit between them through which the disk passes. The general arrangement of the machine is shown in Figure 1. Thin aluminum disks, coated on both sides with magnetic material, are being used in the experimental models at NBS.

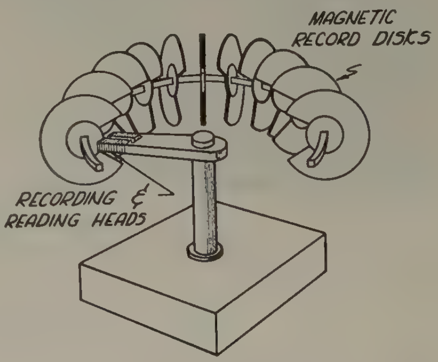


Figure 1. Schematic diagram of the notched-disk memory

The notched-disk memory "doughnut" can be thought

Jacob Rabinow is with the National Bureau of Standards, Washington, D. C.

The magnetic heads employed in the first two models of the notched-disk memory were developed by the Raytheon Manufacturing Company, Waltham, Mass. The small machine was built entirely in the National Bureau of Standards (NBS) Ordnance Division laboratories, while the large machine was built jointly with the Shepard Laboratories, Summit, N. J. The Aluminum Company of America supplied much helpful information as well as the aluminum sheet. Special thanks are due many members of the staff of both the Computer Laboratory and Ordnance Division of the NBS who contributed so many ideas and so much effort to the improvement of the machines described.

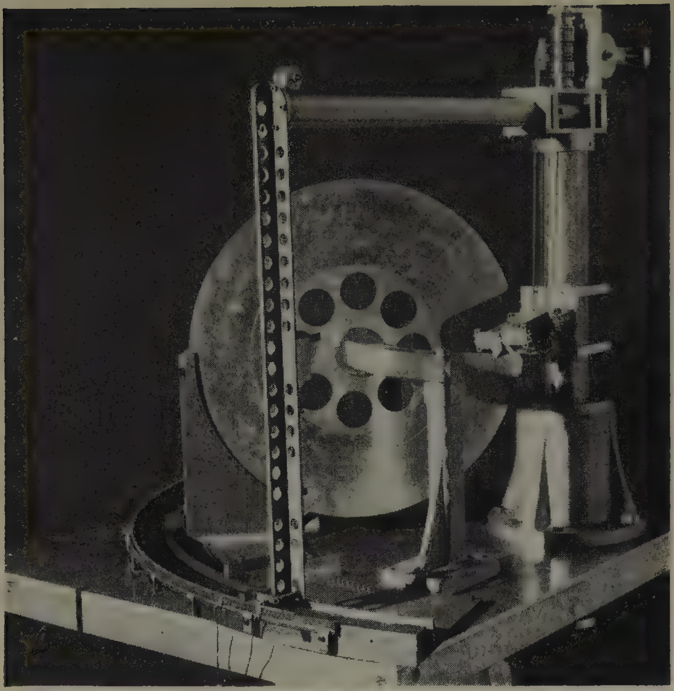


Figure 2. The large notched-disk memory

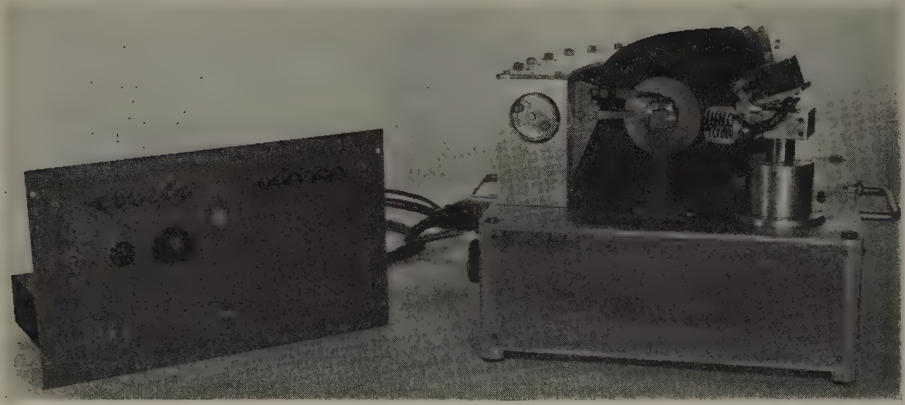


Figure 3. Small notched-disk memory and control unit

of as a kind of book in which round pages are slotted in such a manner that each line on each page can be read by merely spinning the page for one revolution; the notches in the pages provide the "windows" through which the selected page can be read. In other words, the book can be read without being opened.

THE TWO MODELS

The first experimental model of the new memory was designed to have 250 disks, each 20 inches in diameter, arranged in a quarter circle. Merely to simplify construction, the design was subsequently modified to call for only 147 disks (this particular figure has no special significance). Construction of this model, shown partially assembled in Figure 2, is now well along. Following satisfactory proof tests, the machine can be expanded to 588-disk full-circle form.

Soon after work on the first machine was begun, construction was undertaken in the NBS laboratories of a smaller machine for immediate experimental and demonstration use. This smaller machine is shown in Figures 3 and 4. The disks in this machine are 6 inches in diameter. Ten disks are mounted on a shaft bent into a 90-degree circular segment. This machine is also so designed so that it can later be expanded to have a full circle of disks.

The two models, which differ in several design details, are described more fully in the following. It should be pointed out that in building the first models no effort is being devoted to maximizing all of the parameters. Many more disks could undoubtedly be used in a given volume than are being used in these first models, and more information could be stored on each disk.

MAGNETIC DISK DETAILS

In the large machine, the disks are made of 0.006-inch thick aluminum which was supplied to NBS "as drawn." The material, therefore, is quite hard and springy. Both sides of the disk are coated with an Epon plastic in which is embedded a magnetic powder. To the center section of each disk are spot welded two sheets of 0.015-inch thick dural. See Figure 5 for disk parts. The curved shaft that supports the disks has a square cross section. On this shaft are mounted circular washers with square holes. Each of these washers supports one disk. Between the disks are wedge-shaped washers which act as separators. Each of the large disks is provided with a thickened lug at a point of its circumference opposite to the position of the notch. This lug, which extends beyond the normal periphery of the disk, is employed to start the disk on its rotation and to stop it at the end of each cycle. The mechanism for doing this will be described later.

In the small machine, as in the

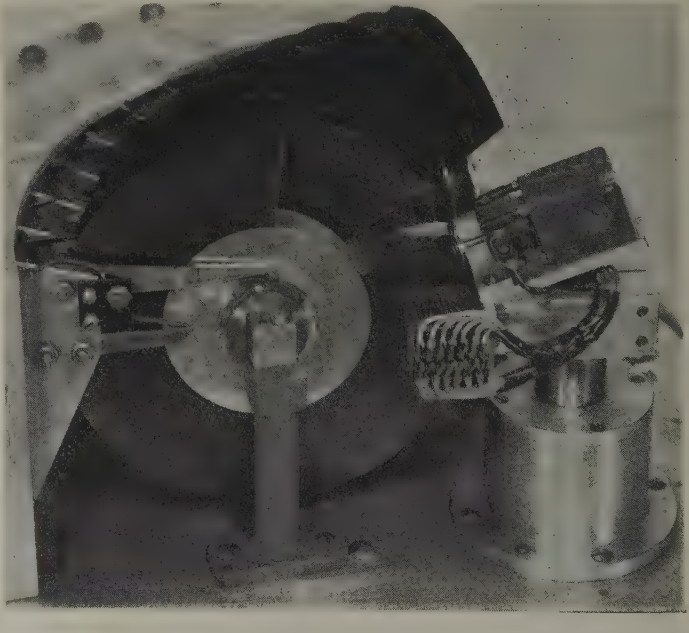


Figure 4. Detail of magnetic heads and notched disks of small disk memory

large, the disks are supported on a square-cross-section circular shaft, but they have attached to them large, thick central washers by means of which they are started in rotation. See Figure 4.

When the work was originally begun, it was hoped that materials harder or tougher than aluminum could be used for the disks. It was found, however, that very few metals are rolled in the 20-inch width required for the large machine and that aluminum provided the best solution, combining as it does lightness and strength. Although other materials are available that could have been utilized for the disks in the small machine, aluminum was used here, too.

DISK DRIVE DETAILS

The problem of rapidly accelerating and decelerating the desired disk presented considerable difficulty. In the large machine a clutch-driven "kicker" mechanism accelerates the disks to full speed in approximately 10 degrees of disk travel. See Figure 6. Two small rubber-tired driving wheels are located near the magnetic heads so that, after the disk is started by the kicker, one edge of the notched section enters between these rubber wheels and then is driven by friction. See Figure 7. When the disk has completed one revolution, it disengages from rubber wheels and is decelerated by a clutch mechanism that acts as a brake. The disk overshoots its final position and is returned slowly to its initial position, and the heads are then again free to travel to the next disk selected. There are both mechanical and electric interlocks to prevent the head assembly from moving toward a new disk should the previous disk not be in its proper standby position.

In the small machine, the disk drive is somewhat different. In order to simplify the machine, each of the disks is provided with a washer at its hub, adapted to be driven by a pawl. An individual solenoid drives this pawl and thus drives the disk into engagement with the rubber wheels. When the disk is being stopped its kinetic energy is absorbed by a spring. See Figure 4.

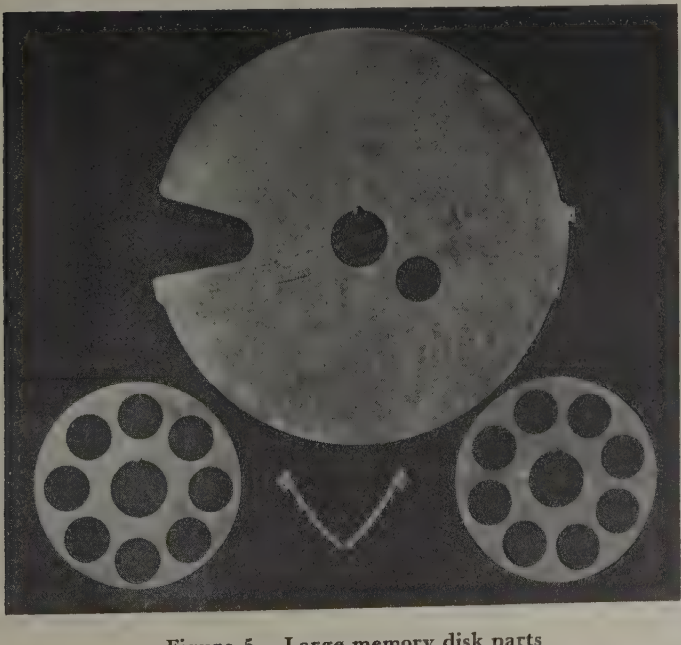


Figure 5. Large memory disk parts

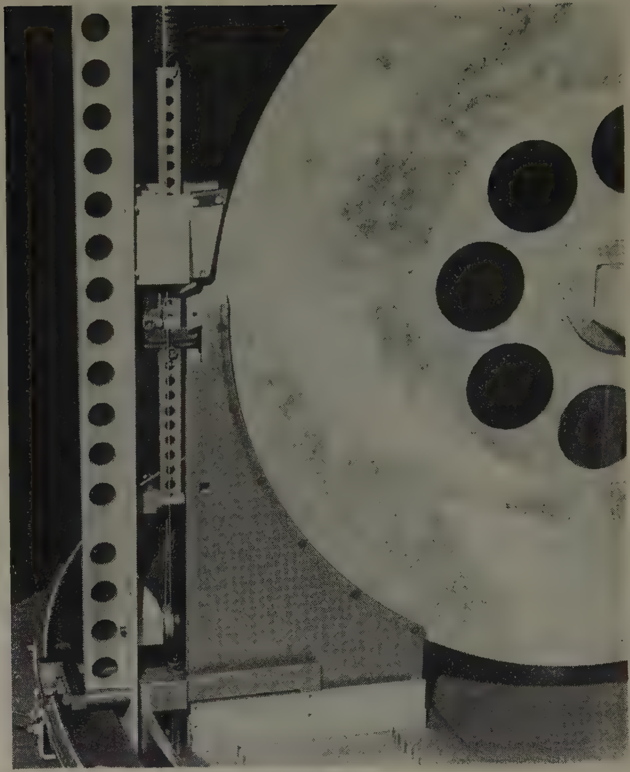


Figure 6. Large memory disk kicker

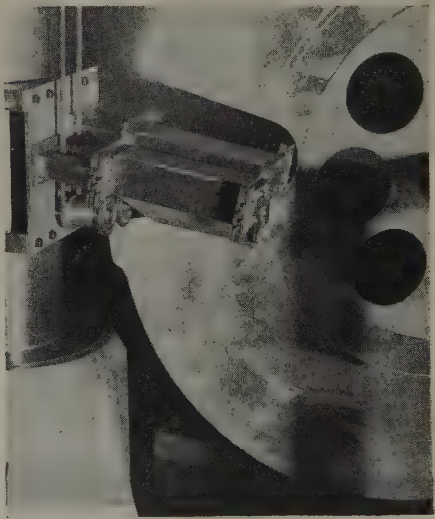


Figure 7. Large memory disk head assembly and disk drive

THE MAGNETIC HEADS

The magnetic heads used in the two machines were developed by a commercial concern under contract with the NBS. They were originally designed for use with magnetic tape to record and read several parallel channels. Each head, as shown in Figure 8, is 1.3 by 1.0 by only 0.073 inch thick. The heads are stacked with thin soft magnetic shields separating them. The over-all thickness of each head and its shield is 0.077 inch. A 28-head bank is mounted on the central shaft of the small machine; 128 heads will be used in the larger version.

Experiments indicate that the heads will perform satisfactorily despite their closeness to each other. Writing

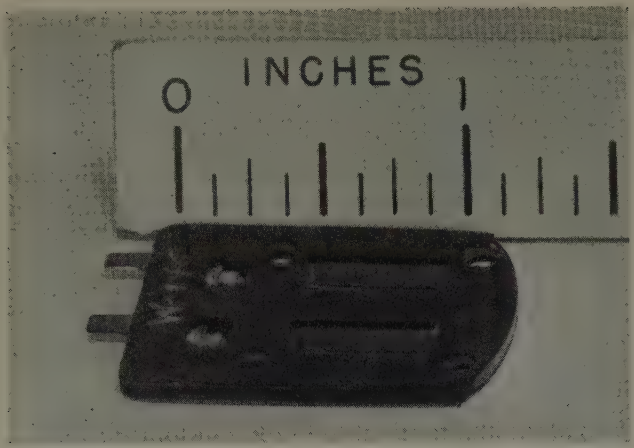


Figure 8. Magnetic head

in one channel does not produce any appreciable record in adjacent channels, and there is no crosstalk except that a channel cannot be read while an adjacent channel is being recorded. This is because the current in the recording channel is large enough to cause pickup by the heads of the adjacent channels. This normally does not give rise to any difficulty since it is not expected that reading and recording will be done simultaneously in adjacent channels. The heads on opposite sides of the disks are staggered by the distance of half a head width so that the magnetic gaps do not face each other. This is done in order to minimize crosstalk.

In the small machine, the two head assemblies on opposite sides of the disk are so spaced that there is more than sufficient room for the disk to pass between them; hence the disk is free to oscillate slightly from one side of the gap to the other. In the original experiments this caused some difficulty with modulation of the recorded pulses. However, it was found that if a large excess of current was used during recording so that saturation of the disk, and perhaps of the head, is always reached, this slight variation in spacing between the disk surface and the heads is of little importance, and the modulation is within acceptable limits.

In the large machine, the two stacks of heads are displaced slightly relative to each other, so that the disk can make contact with each stack without being pinched. See Figures 2 and 7. The head stacks can be adjusted to overhang slightly so that the disk is made to flex slightly in passing between them. This expedient results in a definite pressure between the disk and the working surfaces of the magnetic heads.

Various proposals also have been made for pressing the disks against the heads by means of supplementary springs and for arranging the head assemblies so that air pressure or vacuum could be employed to control the spacing. These expedients are not expected to prove necessary. A great deal depends on how uniform in thickness the disks can be made, and experience so far at the NBS indicates that adequate uniformity can be achieved.

With the heads available, 100 pulses to the linear inch have been recorded without much difficulty. This means that some half-million pulses can be recorded on a single 20-inch disk. If 588 disks are used in the large machine, a total capacity of a quarter of a billion binary digits would result, or somewhat less than one-third as many decimal digits. Maximum information could be stored on each disk by varying the frequency of pulse recording from the inner to the outer line; if the spacing were maintained at 100 pulses to the linear inch, more total pulses could be recorded on an outer groove than on an inner groove. This would require that the frequency of recording be made some function of the radial position of the groove, and this could be done electronically. Whether this complexity is desirable or not depends upon the economics of the over-all system design.

No data are as yet available as to the wear of the heads or of the disks. Preliminary tests made incidental to magnetic studies indicate that wear will not be a serious problem. Some consideration, however, is being given to expedients such as lubrication of the disks and coating them with a protective layer of nonmagnetic material. This last expedient would not only minimize the wear of the disks, and perhaps the heads, but also would provide a fixed gap-spacer so that variations in the air gap would have less effect on the amplitude of the pulses. Attempts are being made to develop methods of keeping fixed, noncontacting, disk-to-head spacing by air-bearing techniques.

HEAD SELECTION AND POSITIONING

No provisions are being made in either of the machines for any mechanism to select a particular head. The connections to all of the heads are being fed out on a cable, and the computer used with the memory will have provisions to select the proper head electronically. Slip rings have been considered, but it is believed at present that a flexible cabling system is preferable. If the head-selection mechanism itself were mounted directly on the head supporting arm, then the number of slip rings required could be greatly reduced. In that case, their use might prove advantageous.

One of the most important problems in the development of these machines is that of positioning the heads rapidly and accurately to line up with the desired disk. In the small machine, the device being used consists

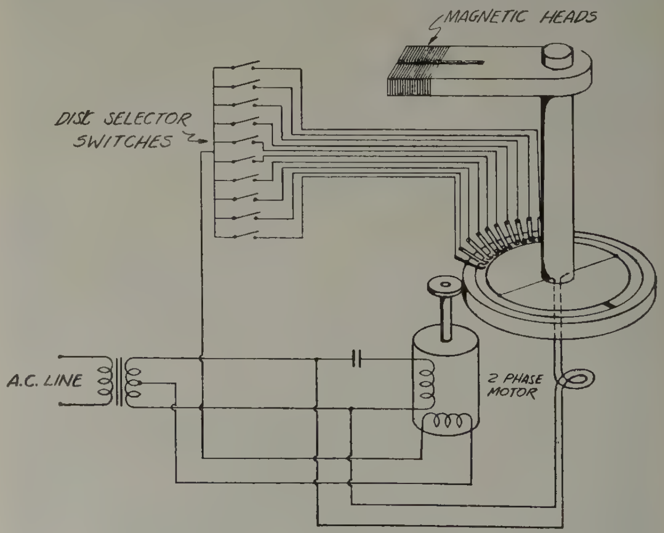


Figure 9. Schematic diagram of head positioning mechanism in small disk memory

essentially of a mechanism familiar to the radio industry for the remote control of radio receivers. See Figure 9. This device suffers from several limitations. One is that there is no provision for decelerating the heads just before they come to the right position; if high speeds are employed, the heads overshoot their correct position and oscillate a few times before coming to rest.

A much more sophisticated head-positioning device is used in the large machine. It consists essentially of a clutch-driven servomechanism which rotates the arm to a position indicated by a slide-wire potentiometer. A "Christmas Tree" decoder is employed to ground various points along the potentiometer wire, and a servomechanism positions the kicker arm, and with it the heads, by moving the slider to the grounded point. See Figure 10. This positioning mechanism has been tested and found satisfactory.

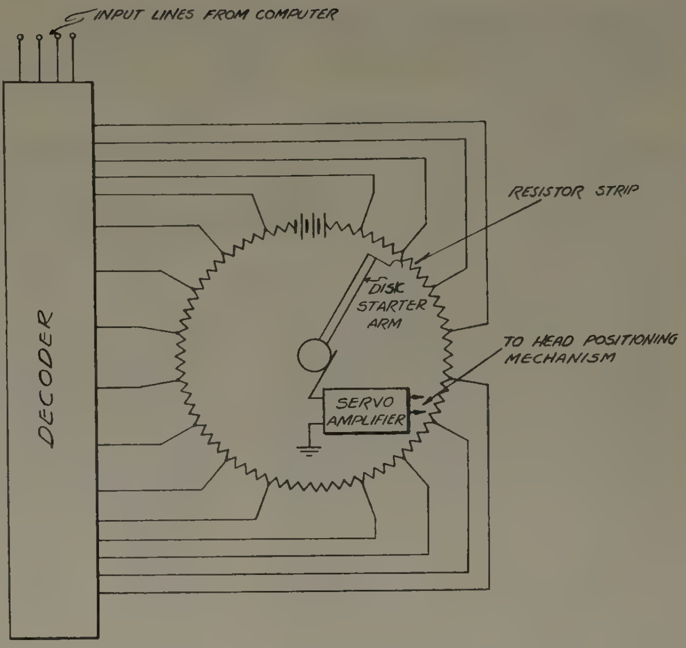


Figure 10. **Schematic diagram of head positioning mechanism in large disk memory**

TECHNICAL POSSIBILITIES AND APPLICATIONS

Many suggestions have been received for other possible forms of the notched-disk memory, and for improvements in some details of the present designs. For instance, use of more than one set of heads in order to increase the speed of access has been suggested. Four sets of heads could be used, spaced 90 degrees apart with the machine arranged to drive the nearest set of heads to the required disk. It seems doubtful that the saving of time would justify the increased cost and complexity.

By using less than an essentially complete disk, a somewhat simpler disk-driving mechanism could be used. Instead of having the disk make a single revolution and then come to a stop, an oscillating type of motion could be employed. A disk sector could be made to swing through the heads and then return to its original position without completing a unidirectional motion. This would simplify the driving mechanism to some extent since it would not have to be disconnected from the disk.

To insure that the velocity of disks through the heads will not appreciably affect the position of the pulses, a marker channel of fixed pulses could be permanently recorded onto one of the lines of the disk so as to serve as a magnetic sprocket for all of the other recording heads. The pulses on the other heads could then be synchronized with this marker channel and the marker channel could be used as an index to a desired pulse or a group of pulses. This would be particularly advantageous where only a small section of recording line is necessary to record a particular amount of data.

Work with the notched-disk memory suggests the possibility that certain intermediate memories in electronic computers, such as those that now use magnetic drums, could be replaced by memories using a single unnotched disk. A single thin, flexible disk driven continually between two sets of heads could be used to record a large amount of information and would have the advantages of being relatively inexpensive and not requiring the mechanical precision needed in a magnetic drum. Due to the rigidity of the drum, the heads are usually mounted very close to it, but avoid actual contact. This calls for a very high degree of mechanical precision. As the disk is light and flexible, it can be permitted to touch the heads without serious harm.

While the foregoing description of the notched-disk memory has been confined to magnetic recording, it is obvious that other recording techniques can be adapted to the mechanical principles of the notched-disk memory. Optical recording and playback could be used with photosensitive materials, using both variable-density and variable-area record tracks. Notched disks of the phonograph type could be used, with the information cut, pressed, or embossed into their surfaces. Perforated disks could be used; the perforations could be punched into the disks either before assembly into the machine or in place, and read by techniques familiar to users of the common business machine cards. Magnetic recording is easily erasable; but this is also its great weakness. In permanent records where erasure is undesirable or unnecessary, other forms of recording might be advantageous.

The availability of suitable information-storage devices is important to progress in the use of automatic information-processing techniques. Desirable features of such devices would seem to include large storage capacity, rapid access time, ruggedness, dependability, and reasonable economy. Since the notched-disk memory principle appears to combine these advantages in unusual degree, information-processing systems using this principle for storage may well come to find important applications in enterprises which must handle, store, and have access to large amounts of routine information. Such systems could be particularly valuable for large organizations, such as the Armed Forces or major distributing firms, where stock control, inventory, and procurement are major problems. Other possible users might include banks, insurance companies, libraries, and certain government agencies, particularly those concerned with such matters as bond issues, taxes, social security accounts, and census.

INSTITUTE ACTIVITIES

1952 AIEE Pacific General Meeting to Be Held in Phoenix, Ariz., August 19-22

The AIEE Pacific General Meeting will be held in Phoenix, Ariz., August 19–22, 1952. Phoenix is a hospitable city and the friendliness, which is everywhere so evident in the Southwest, is truly traditional in the Valley of the Sun. The Westward Ho Hotel has been chosen as the headquarters hotel and all technical sessions and social functions will be held in this completely air-conditioned hotel. Bus and car transportation for all inspection trips will be arranged for at the hotel.

The opening session on Tuesday, August 19, at 10:00 a.m., will be presided over by J. E. Redmond, who is chairman of the General Committee. The Pacific Coast District and Section officers will be introduced at this time. The address of welcome will be given by a prominent citizen of Phoenix.

Regarding transportation, air travel into Phoenix is taken care of by American Airlines and Trans World Airlines. The Rock Island, the Southern Pacific, and the Santa Fe Railroads all have through passenger service to Phoenix and the Pacific Coast, as do the transcontinental bus routes of the Greyhound Bus Lines, Continental Trailways, and the American Bus Lines.

ENTERTAINMENT

Social events and entertainment have been arranged for every evening except Friday.

Tuesday afternoon, August 19, from 3:30 to 6:00 p.m., the Saddle and Sirloin Club in the Hotel Westward Ho has been reserved for a roundup of members and families and a get-acquainted social. On Tuesday evening in the Fiesta Room of the Hotel Westward Ho, a fellowship program has been arranged at which color films of scenic Arizona and its industries will be shown.

On Wednesday evening, August 20, at 6:30 p.m., the hospitality hour for members and families has been scheduled in the Saddle and Sirloin Club of the Hotel Westward Ho. This will be followed immediately at 7:30 p.m. in the Fiesta Room by a genuine Arizona chuck-wagon dinner with western entertainment.

The banquet, entertainment, and dancing for members and families will be held in the Fiesta Room on the mezzanine floor of the hotel on Thursday evening, August 21, at 7:30 p.m.

LADIES' EVENTS

Ladies headquarters will be in the Saddle and Sirloin Club on the third floor of the Hotel Westward Ho. Hostesses will be on hand at all times to extend a welcome, help visitors get acquainted, and answer any questions. Coffee will be served each morning from 10:00 until 11:00 a.m.

On Tuesday, August 19, the ladies are invited to join with the men in the 3:30 p.m. roundup and attend the 8:00 p.m. fellowship program.

For Wednesday, August 20, at 12:00 noon, a luncheon, fashion show, and Indian tribal dancing have been arranged in the Saddle and Sirloin Club. In the evening the ladies again will join the men for the hospitality hour at 6:30 p.m. and the chuck-wagon dinner at 7:30 p.m.

Future AIEE Meetings

Pacific General Meeting (*page 750*)
Hotel Westward Ho, Phoenix, Ariz.
August 19–22, 1952
(*Final date for submitting papers—closed*)

AIEE-IRE Conference on Telemetering
Lafayette Hotel, Long Beach, Calif.
August 26–27, 1952

AIEE Participation in Centennial of Engineering (*page 752*)
Congress Hotel, Chicago, Ill.
September 10–12, 1952
(*Final date for submitting papers—closed*)

Fall General Meeting
Jung Hotel, New Orleans, La.
October 13–17, 1952
(*Final date for submitting papers—closed*)

Middle Eastern District Meeting
Commodore Perry Hotel, Toledo, Ohio
October 28–30, 1952
(*Final date for submitting papers—closed*)

AIEE Conference on Machine Tools
Ten Eyck Hotel, Albany, N. Y.
October 29–31, 1952

AIEE Special Technical Conference on Electrically Operated Recording and Controlling Instruments
Benjamin Franklin Hotel, Philadelphia, Pa.
November 17–18, 1952
(*Final date for submitting papers—closed*)

Joint AIEE-IRE-ACM Conference on Electronic Computers
Park Sheraton Hotel, New York, N. Y.
December 10–12, 1952

(Above, left) The patio of the Westward Ho Hotel, at Phoenix, Ariz., which will be headquarters for the AIEE Pacific General Meeting. (Above, right) Of interest to visitors to the Pacific General Meeting will be the Salt River Power District's Horseshoe Dam on the Verde River. The automatic spillway gates, largest radial gates in the world, were installed in 1950

Thursday, August 21, the ladies committee has scheduled a day of relaxation at the Town and Country Lodge. The ladies may enjoy swimming, playing cards, or just relaxing. Luncheon and entertainment will be provided also. For the evening the banquet, entertainment, and dancing should prove attractive to both the ladies and the members.

INSPECTION TRIPS

Arizona Copper Mines (Wednesday, August 20, 8:00 a.m.). Last year Arizona was the nation's leading copper-producing state; the output was valued at $205,000,000. This trip will take participants through the Globe-Miami District, visting properties of Inspiration Copper Company, Miami Copper Company, and International Smelter Company. Visitors watch open-pit mining operations and see several types of ore recovery. A box-lunch picnic will be held in rugged, beautiful Pinal Mountains. On the return trip to Phoenix in the afternoon, the party will visit Southwestern Arboretum, a unique wonderland of plant life where 10,000 varieties of plants from every continent are growing.

Reynolds Metals Company (Wednesday, August 20, 9:00 a.m.). For those who are interested in manufacturing, a trip has been arranged to visit Reynolds Metals plant, 5 miles west of Phoenix. The world's largest aluminum extrusion plant, it contains nearly $1^1/_2$ million square feet of space and is located on 225 acres of land. This trip will last about 2 hours.

Kyrene Steam Plant (Thursday, August 21, 8:00 a.m.). This 30,000-kw steam generating plant was dedicated and put in operation last June by the Salt River Power District. The state's first completely outdoor power plant, Kyrene is a striking example of the latest design advancements in power plant engineering.

United States Bureau of Reclamation Switchyard (Friday, August 22, 8:00 a.m.). The power that comes into Arizona from Parker Dam on the Colorado River is handled by the Bureau at this switchyard adjoining the Arizona Public Service Company's power plant west of Phoenix. This will be a short trip of about 2 or 3 hours.

In addition to the scheduled inspection trips described, guided tours will be conducted to other industrial and power installations in the Phoenix area. Also, many other scenic trips can be arranged to suit the convenience of delegates and their families. These trips can be made by private automobile, regular sightseeing tours, or by chartered bus or airplane.

Phoenix and the Valley of the Sun are often called the "Sightseeing Center of the Southwest," because there are more (17) National Parks and Monuments in Arizona than in any other state. Within a few hours' drive from meeting headquarters are huge, colorful Indian Reservations; the intriguing charm of old Mexico; cool, pine-clad mountains of northern Arizona.

Every visitor, if at all possible, should include in his plans a trip to the Grand Canyon. Another scenic trip familiar to motorists is U. S. Alternate Route 89. This road goes through Prescott over Mingus Mountain; visits Jerome, perched amazingly on the site of a mountain; travels down into the colorful Verde Valley; and past Oak Creek Canyon, said by many to rival the splendor of the Grand Canyon.

There is much to see and do during a stay in Arizona. For further information or suggestions, or for help in planning the trip, information may be obtained from any member of the Transportation Committee.

HOTEL ACCOMMODATIONS

Rooms have been set aside at the Hotel Westward Ho which is comfortably air-conditioned. Sleeping rooms at the headquarters hotel are limited, but sufficient space has been promised for AIEE requirements. Early reservations will be advantageous and should be made directly to the hotel either by using the hotel reservation card furnished with the mailed announcement or by addressing Aiken Mathews, Manager, Westward Ho Hotel, Phoenix, Ariz. All requests should specify type of accommodations, number in party, date and time of arrival, and date of departure.

Typical room rates are as follows (all with baths):

Room, single bed	$ 6.00 – 7.00
Room, double bed	$ 8.00 – 9.00
Room, twin beds	$ 9.00 –10.00
Suite, two rooms (two people)	$15.00 –20.00*
Suite, three rooms (four people)	$30.00*–35.00*

* Kitchenette apartments.

GENERAL MEETING COMMITTEE

The members of the Pacific General Meeting Committee are: J. E. Redmond, *Chairman;* T. M. Morong, *Vice-Chairman;* Americo Lazzari, *Secretary;* Walter Willson, *Hotels;* M. M. Bridgwater, *Treasurer and Finance;* Mrs. J. E. Redmond, *Ladies;* J. T. Kimball, *Entertainment;* M. R. Llewellyn, *Sports;* G. H. Groh, *Technical Programs;* E. A. Thomas, *Registration;* C. A. Poppino, *Inspection Trips;* C. R. Smith, *Transportation;* J. C. Clark, *Students;* Ben Ferguson, *Publicity;* I. G. Jenkins, Fay Percy, William Doak, *Members at Large.*

Tentative Technical Program

Pacific General Meeting, Phoenix, August 19-22

Tuesday, August 19

10:00 a.m. Opening Ceremony

J. E. Redmond, presiding

Introduction of Pacific Coast Institute officers and presentation of Pacific Coast Section officers—J. E. Redmond, General Chairman

Address of Welcome

2:00 p.m. Transmission and Distribution

C. G. Mansfield, presiding

52-242. Field Tests on 135-Kv 3.5-Million-Kva Low-Oil-Content Circuit Breakers. *Paul Wildi, W. H. Clagett, Lloyd Morgan,* Pacific Oerlikon Company

52-243. Radio Influence From Power Transmission Lines—Effects of Wind, Dust, and Smoke. *G. S. Smith, A. B. Jacobson,* University of Washington

CP. Application of Transmission-Line Mutual Impedance Equivalent Circuits.** *M. J. Lantz,* Bonneville Power Administration

52-252. Structure Limitation Charts for Transmission Lines. *T. M. Austin,* Lakewood, Colo.

52-253. A Simplified Sag Tension Method for ACSR. *C. A. Jordan,* General Cable Corporation

2:00 p.m. Electronics

Otto Mangum, presiding

52-244—ACO.* Cathode Drift Compensation in D-C Amplifiers. *J. W. Rittenhouse,* School of Mines and Metallurgy, University of Missouri

CP.* The Responses of Certain Basic Circuits to a Trapezoidal Pulse. *T. J. Higgins,* University of Wisconsin; *P. Kaufman, K. G. Black,* graduate students, University of Wisconsin

Wednesday, August 20

9:30 a.m. Safety

Noel B. Hinson, presiding

CP. Who Is Responsible for Safety?** *William Ismay,* Arizona Public Service Company

CP. Design Engineers' Responsibility for Safety.** *E. C. Hunt,* Pacific Gas and Electric Company

CP. Electric Work Injuries in California Industries.** *E. E. Carlton,* Safety Engineer, State of California

CP. Electrical Safety in Great Britain.** *F. L. Goss,* Water and Power Department, City of Los Angeles

9:30 a.m. Western Mining Applications

A. B. Chafetz, presiding

CP. Open-Pit Ore Haulage.** *M. C. Potter,* Westinghouse Electric Corporation

CP. Portable Underground Dry-Type Power Centers.** *Henry Gates,* Westinghouse Electric Corporation

CP. Electrical Characteristics of Electrostatic Precipitators Applied to the Mining and Smelting Industries.** *R. M. Anderson,* Westinghouse Electric Corporation; *E. J. Stocker,* A. S. and R.

9:30 a.m. District Executive Meeting

2:00 p.m. Western Mining Applications

Carl A. Poppino, presiding

CP. The Idaho Phosphorus Industry, Its Effect on Snake River Hydro Developments.** *J. G. Miller,* Westvaco Chemical Division, Food Machinery and Chemical Corporation

CP. Electric Braking System for Mining Locomotives.** *Felix Berra,* Phelps Dodge Corporation; *R. D. Call, B. E. Rector,* Westinghouse Electric Corporation; *A. B. Chafetz,* International Minerals and Chemical Corporation

CP. A-C Distribution in Open-Pit Copper Mines.** *Felix Berra,* Phelps Dodge Corporation; *D. B. Carson, C. A. Poppino,* General Electric Company

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* **ACO:** Advance copies only available; not intended for publication in *Transactions.*

** **CP:** Conference paper; no advance copies are available; not intended for publication in *Transactions.*

2:00 p.m. Transformers

Kenneth V. Fletcher, presiding

CP. Local Conditions Affecting Loading Standard 55-Degree-Centigrade Transformers.** *F. L. Roe, Louisa F. Simons,* Salt River Power District; *K. V. Fletcher,* General Electric Company

CP. The Effects of Solar Radiation on Transformer Cooling in the Salt River Project.** *S. A. Moore, W. J. Grasmoen*

CP. Loading of Transformers by Copper Temperature.** *W. L. Carey,* Portland General Electric Company

2:00 p.m. Student Technical Session

Professor James C. Clark, presiding

Thursday, August 21

9:30 a.m. Metering and Relaying

M. A. Bostwick, presiding

CP. A New Time, Interval, and Sequence Recorder.** *H. A. Holmes,* Prescott, Ariz.

52-245—ACO.* A Wide-Range Frequency Recorder and Indicator for Electric System Use. *R. M. Stuart,* General Electric Company; *F. S. Benson,* Pacific Gas and Electric Company

9:30 a.m. Feedback Control Systems

Robert H. Hartley, presiding

52-246. Analogue Methods for Optimum Servomechanism Design. *F. C. Fickeisen, T. M. Stout,* University of Washington

52-247. Analogue Computers for Feedback Control System. *R. A. Bruns, University af California*

9:30 a.m. AIEE Board of Directors Meeting

9:30 a.m. Industrial Power Systems

E. S. Dibble, presiding

CP. Secondary Networks Provide Service Continuity in Process Plant.** *Walter Hahn,* Bechtel Corporation; *P. Belsky,* Westinghouse Electric Corporation

—PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES of papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Program Committee ultimately will be published in the bimonthly publications and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

CP. Power Supply for Nuclear Research Laboratory.** *Carl Graver,* University of California

2:00 p.m. Microwave Applications

T. A. Phillips, presiding

CP. Carrier Current Tests on Salt River Power District's 110-Kv Loop System.** *S. M. Chalmers, F. W. Reece*

52-248. Microwaves in the Electric Power Field. *W. A. Derr, H. W. Lensner, D. F. Burnside,* Westinghouse Electric Corporation

2:00 p.m. System Engineering

N. Pike, presiding

52-249. The Davis Dam Power Development. *S. M. Denton, H. O. Britt,* United States Bureau of Reclamation

52-250—ACO.* The Parker-Davis Power System. *W. M. Doak,* United States Bureau of Reclamation

52-251. Influence of Power System Design on Protection Relaying. *J. L. Blackburn,* Westinghouse Electric Corporation

Friday, August 22

9:30 a.m. Power Generation

Walter T. Lucking, presiding

CP. Cross Cut—40 Years of Power Plant Progress.** *W. J. Grasmoen, H. F. Hudson,* Salt River Power District

CP. "Kyrene"—Salt River Project's Outdoor Steam Plant Designed for the Southwest Climatic and Operating Conditions.** *T. M. Morong, E. J. Lauerman,* Salt River Power District; *I. R. Caraco,* Bechtel Corporation

CP. Intercooling of Windings of Turbine-Generator Units.** *Lee Kilgore,* Westinghouse Electric Corporation

CP. Applications of Gas Turbines for Central Power Stations.** *Stephens,* Westinghouse Electric Corporation

9:30 a.m. Lighting (Illuminating Engineering Society)

J. D. Whitnell, presiding

Lighting Yesterday and Tomorrow. *B. H. Hartley,* Falcon Engineering

Engineering Aspects of Illumination. *S. S. Benson, Jr.,* Benjamin Electric Company

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AIEE Announces Plans for Participation in Centennial of Engineering in Chicago

The AIEE announces an outstanding program marking the participation of the AIEE in a great convocation of 50 engineering organizations celebrating the founding of the first professional engineering society in 1852. The Convocation of the Centennial of Engineering—1952 will be held in Chicago, Ill., September 3–13, 1952, and is expected to attract more than 25,000 engineers from the United States and many foreign countries. (ee also poge 771.)

Five technical sessions will be co-ordinated with luncheons and an intersociety banquet highlighting the convocation. The program has been designed to portray the progress in the principal fields of electrical engineering and the probable future trends in these areas. An unparalleled and perhaps unique opportunity is thus presented to Institute members to grasp the significance of the general development of their profession and to form a better concept of their own role in planned engineering progress.

Chicago, host city to the convocation, offers many recreational and cultural opportunities for the visitor which are especially appropriate to the celebration of the Centennial. The Museum of Science and Industry will present twice-daily a musical pageant entitled "Adam to Atom" presenting a panorama of mankind's advance by the utilization of engineering and scientific achievement. The museum also will feature an exhibit portraying how scientific discoveries have been applied by engineering and industry to produce our high standard of living. The Shedd Aquarium, Museum of Natural History, Adler Planetarium, Chicago Historical Society, Chicago Academy of Sciences, and the Art Institute are all within a short distance of the Congress Hotel, AIEE headquarters for the convocation. The famed Chicago Zoological Gardens are located in Brookfield, a half-hour from downtown Chicago. Information on other points of interest will be available at headquarters.

PROGRAM

The participation of the AIEE in the Centennial of Engineering will begin with an intersociety luncheon on Wednesday, September 10, at the Conrad Hilton Hotel, and will be followed in the afternoon by the program of the General Applications Division. The general intersociety banquet of the Centennial will be held on Wednesday evening with a speaker of national prominence to be announced.

The Power Division and the Industry Division will present programs on Thursday, September 11. AIEE President D. A. Quarles will be the speaker at the noon luncheon in the Florentine Room of the Congress Hotel.

The technical program for Friday, September 12, will be sponsored by the Communications Division and by the Basic Sciences and Electronics Division. The speaker at the Friday luncheon will be M. J. Kelly, President, Bell Telephone Laboratories.

LADIES PROGRAM

AIEE plans for ladies' entertainment include a coffee hour each morning, afternoon tea, and a special luncheon and style show at Marshall Field and Company featuring both modern dress and costumes of 100 years ago, especially designed to celebrate the Centennial of Field's famous store. Transportation to points of special interest is being planned by the Centennial organization and information on these tours will be available at the registration desk.

REGISTRATION

The registration desk will be open daily at 9:00 a.m. beginning Wednesday, September 10. Arrangements will be made to expedite the registration of those who send in advance registration cards. The usual registration fees for members and for nonmembers will be waived. Enrolled students and the immediate families of members will be registered without charge.

HOTEL RESERVATIONS

Hotel rooms should be reserved by writing directly to the Congress Hotel stating that the reservation is for the AIEE Participation in the Centennial of Engineering. To be certain of hotel accommodations, reservations should be sent in preferably by August 15, and certainly not later than September 1. Reservations should be sent to Miss Helen Swatniki, Reservation Department, Congress Hotel, Chicago 5, Ill. A copy of the reservation letter should be sent to W. A. Knight, Hotel Committee, care of General Electric Company, 840 South Canal Street, Chicago 80, Ill.

Rooms will be available at the following rates:

Single Room: $5.50, 6.00, 6.50, 7.00, 8.00 and up
Double Room (double bed): $8.50, 9.00, 9.50, 10.00, 10.50 and up
Double Room (twin beds): $9.50, 10.00, 10.50, 11.00, 11.50 and up
Parlor Suites (two rooms): $20.00, 25.00 and up

All rooms are with combination tub and shower baths.

GENERAL COMMITTEE

The members of the General Committee for the AIEE Participation in the Centennial of Engineering are: F. V. Smith, *General Chairman;* J. C. Woods, *Vice-Chairman;* R. C. Ericson, *Secretary;* H. L. Martin, *Treasurer;* F. H. Lane, *Finance;* W. M. Ballenger, *Hotel;* Mrs. T. G. LeClair, *Ladies;* J. F. Calvert, *Papers;* E. R. Whitehead, *Publicity;* N. C. Pearcy, *Registration;* M. M. Brandon, T. H. David, Jr., L. F. Hickernell, T. G. LeClair, R. D. Maxon, E. L. Michelson, T. B. Montgomery, R. R. O'Connor, and J. D. Ryder, *Members-at-Large.*

View of the skyline of Chicago where the Convocation marking the Centennial of Engineering will take place September 3–13

Tentative AIEE Technical Program

Centennial of Engineering—1952, Chicago

Wednesday, September 10

9:00 a.m. Registration

12:00 noon. Luncheon, Auspices Centennial of Engineering, Conrad Hilton Hotel

2:00 p.m. General Applications Division

T. H. David, presiding

A Century of Electrical Engineering in Land Transportation. *H. F. Brown,* Westinghouse Electric International Company

Progress in Applications of Electrical Engineering in Air Transportation. *D. E. Fritz,* Jack and Heintz Precision Industries

Small Electric Houseware Appliances—100 Years. *Frank Thornton, Jr.,* Westinghouse Electric Corporation

Electric Lighting in the First Century of Engineering. *R. L. Oetting,* General Electric Company

Banquet, Auspices Centennial of Engineering

Thursday, September 11

9:00 a.m. Power Division

L. F. Hickernell, presiding

Progress and Future Trends in Electric Transmission. *S. B. Crary,* General Electric Company; *I. W. Gross,* American Gas and Electric Company; *C. F. Wagner,* Westinghouse Electric Corporation

Progress in the Art of Power Generation. *A. C. Montieth, A. A. Johnson,* Westinghouse Electric Corporation

Economic Utilization of Electric Power Equipment. *Herman Halperin,* Commonwealth Edison Company

Lightning as a Hazard to Power Systems. *K. B. McEachron,* General Electric Company

12:00 noon. Luncheon, Florentine Room

Speaker. D. A. Quarles, President AIEE: "Organization of the Engineering Profession."

2:00 p.m. Industry Division

T. B. Montgomery, presiding

Electric Power in Industry. *F. R. Benedict,* Westinghouse Electric Corporation

Feedback Control System Engineering—An Expanding Professional Field. *G. S. Brown,* Massachusetts Institute of Technology

Welding Applications in the Electrical Industry. *Julius Heuschkel,* Westinghouse Electric Corporation, auspices of American Welding Society

Friday, September 12

9:00 a.m. Communication Division

F. B. Bramhall, presiding

The Impress of Enterprise Upon Telegraphy's First Century. *I. S. Coggeshall,* The Western Union Telegraph Company

The Development of Telephony in the United States. *A. B. Clark,* Bell Telephone Laboratories

The First 50 Years of International Radio Communication. *Haraden Pratt,* Telecommunications Advisor to the President of the United States

Historic Highlights in Developing the Radiobroadcasting and Television Arts. *O. B. Hanson,* National Broadcasting Company

12:00 noon. Luncheon, Florentine Room

Speaker. M. J. Kelly, President, Bell Telephone Laboratories: "The Contributions of Communications and Electronics to Our National Strength and Culture."

2:00 p.m. Science and Electronics Division

Professor J. D. Ryder, presiding

Behavior of Magnetic Materials. *R. M. Bozorth,* Bell Telephone Laboratories

The Development of Electronics and the Foundation for Industrial Application. *J. E. Hobson,* Stanford Research Institute

Applications of the Bonded-Wire Strain Gauge in Civil Engineering. *F. G. Tatnall,* Baldwin-Lima-Hamilton Corporation

Computing: Past, Present, and Future. *W. H. MacWilliams, Jr.,* Bell Telephone Laboratories

Manpower Conference Planned for Engineering Centennial

A Conference on Manpower Utilization and National Security is being arranged by the Engineering Manpower Commission of Engineers Joint Council (EJC) during the Centennial of Engineering in Chicago, Ill. The conference will be held on September 7, 1952, at the Conrad Hilton Hotel. Dean O. W. Eshbach of Northwestern University's Technological Institute will act as general chairman.

The conference will begin with a morning session at 10:00 a.m. which will feature a paper on "Manpower Utilization and National Security" by Carey H. Brown, Chairman of the Engineering Manpower Commission, and manager of engineering and manufacturing services for the Eastman Kodak Company, Rochester, N. Y. This paper will highlight the position of the Engineering Manpower Commission with respect to such manpower problems as: Universal Military Training; Universal Military Service; expanded Reserve Officers' Training Corps proposals; unified Reserve legislation; Selective Service; and industrial utilization of specialized personnel in short supply. It will be followed by a prepared discussion by a panel of invited discussors from education, government, and industry.

In the afternoon, at 12:30 p.m., a luncheon will be held in the hotel's Normandie Lounge, and an Open Forum is scheduled for 2:00 p.m. It will be in the form of a question and answer session with speaker and discussors as a panel to answer the questions submitted. From 4:00 to 4:30, a summary of the conference will be presented by a prominent industrialist.

1952 Centennial of Engineering Will Portray 100 Years of Progress in the Engineering Profession

This summer, during July, August, and September, Chicago will be the scene of the Centennial of Engineering which will describe graphically, in various forms, the progress which has been made in the engineering profession in the past 100 years. Although engineering, of course, is more than a century old, it was in 1852 that the first engineering society was formed—the American Society of Civil Engineers—and the Centennial thus commemorates 100 years of organized engineering activity.

The purpose of the Centennial is twofold: first, in this period of critical shortage of engineering manpower, it should revitalize an interest in the engineering profession for the youth of the country; second, it should bring into focus the important contributions that engineers have made to the American way of life, things such as the electric light, the radio, and the refrigerator which we take for granted today. It is thus the purpose of the Centennial to present to the public an entertainment spectacle and, at the same time make the audience aware of the principles which have made America great, and of the role of the engineering profession in this greatness. This will be accomplished in three principle ways:

1. By means of a special engineering exhibit which will be integrated with the other prominent exhibits now located at Chicago's Museum of Science and Industry.
2. By means of a stage production depicting engineering advancement.
3. By an international convocation of all types of engineers. In addition, a special commemorative stamp will be issued and a motion picture film is to be released.

The first aspect of the Centennial, the engineering exhibit, will include nine displays ranging from aluminum to lubrication. For example, the Cincinnati Milling Machine Company's exhibit of machine tools will explain the six basic types of machine tools; demonstrate how the centerless grinder mass produces such items as bowling and billiard balls and suture needles; and will reproduce all the steps in the manufacture of a simple item such as an ash tray.

The stage production, "From Adam to Atom," will tell the story of Man's progress and the role of the engineer and scientist in this advance. The production's 27 scenes will include the invention of the wheel, Gutenberg's invention of the printing press, and the works of Whitney, Bell, Morse, and Edison. Other scenes will depict the Columbian Exposition, the building of the Panama Canal, Ford's mass-production concept, and the story of rubber.

The third aspect of the Centennial of Engineering will be the Convocation of Engineers to be held September 3–13. During those 10 days, some 51 engineering societies and associations plan to hold full-scale national technical or special engineering meetings. As a result, an engineer attending the Convocation will have an opportunity to learn from the recognized experts in almost any engineering field. In addition, there will be technical symposia in a large number of specific fields.

1952 Summer General Meeting in Minneapolis Marks Anniversary of Minnesota Section

The 68th annual Summer General Meeting of the AIEE in combination with the 50th anniversary of the AIEE Minnesota Section was held at the Nicollet Hotel, Minneapolis, Minn., June 23–27. The attendance of 1,786 members and guests represented all parts of the United States and Canada.

ANNUAL MEETING

The Annual Meeting of the AIEE, held in the Ballroom of the Nicollet Hotel on Monday morning, was opened by R. R. Herrmann, General Chairman of the Summer General Meeting Committee, who welcomed the members and then introduced AIEE President F. O. McMillan, who presided over the remainder of the meeting.

H. H. Henline, AIEE Secretary, presented a condensed report of the Board of Directors. The AIEE membership as of June 1952 was 43,267, an increase of 3,584 members in the past year. Mr. Henline also gave a résumé of Treasurer W. I. Slichter's report, which showed that the Institute's finances are in an unusually healthy state.

The report of the Committee of Tellers, which announced the election of the following AIEE officers, was also read by Mr. Henline: for *President*, D. A. Quarles; for *Vice-Presidents*, W. S. Hill, M. D. Hooven, W. L. Cassell, C. M. Lytle, and Thomas Ingledow; for *Directors*, A. C. Muir, N. C. Pearcy, and C. S. Purnell; for *Treasurer*, N. S. Hibshman.

In another report from the Committee of Tellers, Mr. Henline announced that the amendments to the Constitution had been voted on by the membership and that they had been adopted by a large majority.

At this point President McMillan introduced President-elect D. A. Quarles and presented to him the president's badge. In his reply, Mr. Quarles thanked the Board of Directors and the headquarters staff for their assistance and paid tribute to Professor W. I. Slichter, the retiring treasurer, for his untiring efforts in the Institute's service.

Mr. Quarles went on to say that everyone should be alert to modern engineering fields and that electrical engineers in particular should be glad to have the Institute as a professional society. In order to progress, there must be an expanding scope and that this has been recognized by the Institute is evidenced by the establishment of new committees and the new publication policy, which was accepted by the membership in last winter's poll.

President McMillan announced the retirement of Professor W. I. Slichter as Institute treasurer and exhibited the scroll prepared by direction of the Board of Directors for presentation to Professor Slichter thanking him for his many years' work in that office.

President McMillan then introduced A. H. Kehoe, Chairman of the Lamme Medal Committee, who gave a short history of the establishment of the medal; F. S. Rice, who read C. C. Boswell's remarks on the career of the medalist; and Arthur E. Silver, retired, Ebasco Services, Inc., to whom President McMillan presented the gold medal. Mr. Silver's response and other addresses pertaining to the Lamme Medal will be found on pages 698–702 of this issue.

The final address of the program was "Our Achievements" by President McMillan. The full text of this presentation will be found on pages 677–80 of this issue.

GET-TOGETHER LUNCHEON

Following the Annual Meeting, at noon there was a get-together luncheon at which J. R. North, Vice-President of District 5, introduced Dr. James L. Morrill, President of the University of Minnesota, who spoke on "Industry, Ideas and Ideals."

Every generation, Dr. Morrill supposed, feels itself to have lived through the most marvelous miracles of modern history, but it is difficult to think of an age so epochal as ours. In this age we have seen validated the broad definition of engineering as the art of directing the great sources of power in nature for the use and convenience of man. These things alone: the automobile, the airplane, and the radio, have opened new horizons of opportunity, appreciation, and richer living for all mankind.

In speaking about the 5-year engineering course at the University of Minnesota, Dr. Morrill said that they had been criticized because of the shortage of engineers today. They feel justified, however, in giving the extended course inasmuch as it gives the student a rounder point of view—the broader aspects which are all too often lacking in engineering students, who are disturbed by confusion of debatable facts and ideas in the nonmaterial world with which men must contend.

GREAT LAKES DISTRICT PRIZE AWARDS

At the luncheon on Tuesday, with Director N. C. Pearcy presiding, Vice-President North presented the Great Lakes District Prize Awards for the best technical papers. The winners were as follows:

District First Prize. For the paper entitled "Resistance Commutation" by F. D. Olney, Hughes Aircraft Company.

District Second Prize. For the paper entitled "Induced Currents in High-Capacity Enclosures" by E. C. Killian, Delta-Star Electric Company.

District Branch First Prize. For the paper entitled "Report on Design of an Electronic Pulse Generator for Physiological Research" by Richard F. Grantges, University of Minnesota.

REACTOR DEVELOPMENT

At a luncheon on Wednesday, over which Dr. H. E. Hartig, vice-chairman of the General Committee, presided, Dr. Lawrence R. Hafstad, Director of the Division of Reactor Development, Atomic Energy Commission, addressed the members on "Reactor Development Program of the Atomic Energy Commission."

After a brief history of how atomic fission has developed since the end of World War II, Dr. Hafstad gave some of the facts about the program with which electrical engineers should be familiar.

The reactor is a machine to reduce nuclear energy into useful energy. The amount of energy in one pound of fissionable material equals the energy in 2,600,000 pounds of coal. This energy in a reactor, unlike that in an atomic bomb, can be released slowly and under control.

Reactors must be built on such a large scale because the high-speed neutrons have a mean free path in uranium 235 of 10 centimeters and so there must be sufficient material on which they can react and release electrons at a high energy level, which is controllable.

In answer to the question of why we want to build reactors, Dr. Hafstad stated that results from the reaction and heat makes steam and steam can be used to drive prime movers.

ENGINEERING—ITS CENTENNIAL AND FUTURE

An address, "Engineering—Its Centennial and Future," by Past-President T. G. LeClair, was the feature of the Thursday luncheon with E. A. Willson, chairman of the Minnesota Section, presiding. Mr. LeClair colorfully described the occasion, the objectives, the special engineering exhibits, and the dramatizing of advancement as well as the international convocation of engineers, which was interwoven with the inspirational effects on the future.

Beginning with the early building of the pyramids, the great wall of China, the military engineers, by 1852 there was a sufficiently large number of nonmilitary engineers to warrant the formation of the American Society of Civil Engineers which the Centennial commemorates. The celebration is also important at this time in view of the engineering manpower shortage as it serves the best way to arouse interest and enthusiasm in the dramatic achievements of the past, the dynamic developments of the present, and the incredible forecasts of the future. From personal experiences Mr. LeClair pointed out how the electric light, the refrigerator, the radio, television, and the automobile, and many other achievements during the past century, are accepted as commonplace necessities.

He pointed out that the purpose of the Centennial of Engineering will be to present to the public an entertainment spectacle which will make the audience aware of the principles which have made America great, and, at the same time, this will stimulate future inspiration. He told in detail how this will be accomplished in three principal ways, including the stage production of 27 action-packed scenes on three revolving stages which will tell the story of Man's progress and the role of the engineer and the scientist in this advance. The Convocation of Engineers, which will be held between September 3d and the 13th, and in which some 51 engineering societies and associations will hold full-scale national technical meetings, is something which no engineer can afford to miss. For further details of the Centennial see the news item, "1952 Centennial of Engineering Will Portray 100 Years of Progress in the Engineering Profession," on page 754 of this issue. For details of AIEE participation in the Convocation, see pages 752 of this issue.

WINNERS OF SPORTS PRIZES

At the luncheon on Friday prizes were presented to the winners of the golf tournament, and also of the boat races which were held on Lake Calhoun. Prizes were presented by R. G. Lynn, chairman of the Sports and Prize Meets Committee, and the winners were announced by H. H. Ratcliff.

Donald A. Quarles, President-elect, was presented with a pair of bookends for his low gross score of 89 in the golf tournament. Low net was won by E. W. Rockwell of Los Angeles, who was presented with a desk set. The low gross runner-up, A. L. Starr of Kansas City, received an ash tray. The low net runner-up was E. C. Riall, Jr., of Shreveport, La., and the blind bogey was won by Dixon Lewis of Washington, D. C.

The boat race on Lake Calhoun marked an innovation as each of the ten boats carried a Vice-President of the Institute. The prizes were awarded to the crew or skippers. First place was won by District 1 with Vice-President-elect W. Scott Hill in the boat, and the trophy was presented to D. Ratcliff. Second place went to District 4 with E. S. Lammers, Vice-President, and the skipper Tom Jamieson. Third place went to District 2 with Vice-President J. C. Strasbourger and W. B. Kouwenhoven in the boat, which was skippered by Midge and Sally Daunt. It was reported that the boat for the Great Lakes District with Vice-President North, skippered by Sheldon Brooks, struck a buoy and came in last.

COMMITTEES

The members of the Summer General Meeting Committee which made the arrangements were as follows: R. R. Herrmann, *General Chairman;* Dr. H. E. Hartig, *Vice-Chairman;* A. J. Hendry, *Treasurer;* H. P. Bruncke, *Secretary;* D. D. Ewing, *Director* (*National*); J. R. North, *Vice-President* (*District 5*); R. B. Wiprud; G. B. Germain; R. N. Fairman.

The chairman of the subcommittees were as follows: *Entertainment*, E. H. Hagensick; *Finance and Budget*, R. H. Olson; *Hotel Reservations*, Lincoln Rietow; *Inspection Trips*, P. G. Bowman; *Student Activities*, J. H. Kuhlmann; *Sports and Prize Meets*, Richard Lynn; *Fiftieth Anniversary*, H. W. Meyer; *General Sessions*, W. H. Gille; *House and Equipment*, M. I. Risley; *Printing*, E. A. Wold; *Registration*, E. B. Doescher; *Publicity*, R. M. Kalb; *Transportation*, H. E. McWethy; *Ladies' Activities*, Mrs. H. E. Hartig; *Technical Program*, P. A. Cartwright.

Monday Forum Considers Shortage of Engineers; Remedial Measures Discussed

In Monday's well-rounded forum on "The Shortage of Engineers," Colonel Carey H. Brown, chairman of the Engineering Manpower Commission (EMC) of Engineers Joint Council, outlined "The Situation Today and the Outlook for the Future." Doctor O. W. Eshbach, Dean, Technological Institute, Northwestern University, prepared a paper on "Encouragement of Technical Training for Young People" which was presented by R. H. Cole, professor of psychology. J. Harold Foote, president, Commonwealth Services, Inc., presented "A Program of Action for Local Sections," and in specific discussion G. T. Minasian, chairman of the AIEE Public Relations Committee, told how publicity can help, and S. P. Shackleton, member of the Committee on Student Guidance, Engineers' Council for Professional Development (ECPD), gave the case histories of successful student guidance work in the New York area. The presentations were followed by general discussion by the delegates. The subjects and the speakers were ably introduced by H. A. Dambly who presided and pointed out that the 95 Sections and 45 Subsections of the AIEE were in a position to command attention in their communities and tell the story of engineering.

In presenting the situation today and the outlook for the future, Colonel Brown outlined studies by the EMC which made a survey of industries during the summer of 1951 and established the fact that a shortage of 80,000 engineers exists, excluding demands by atomic energy work and the Armed Forces. He explained that the actual extent of the shortage is a matter of variable opinions. Based upon the 28,000 engineers who were graduated in 1952 and present enrollments in the engineering colleges, about 20,000 will be graduated in 1953, 17,000 in 1954, and 19,000 in 1955. The upturn in 1955 is encouraging and he expressed hope that it would continue.

Colonel Brown attributed the present shortage of engineers to the low birth rate during the early 1930's, the drafting of future engineers and scientists during the war, and the loss of science teachers; also, the complexity of modern design and production requires more engineers. The design of military equipment has placed a high requirement on the demand for engineers and the armament race is a race not only of production, but of technical superiority. If war should come, the demand for engineers would be very great and there also would be a pent-up demand for civilian goods after the war. Failure to maintain our superiority in military equipment and in industry would be disastrous. For further details, see "What Are the Opportunities in Engineering and Science?" by Carey H. Brown (*EE, May '52, pp 452–4*).

With respect to the encouragement of technical training for young people as reported by O. W. Eshbach, it was established on a long-term basis that the number of engineers and industrial output have shown comparable growth in the last 52 years except for the depression years and the war economy of the 1940's, which represent extreme fluctuations. Both the industrial output and the number of engineers may be represented by a compounded rate of growth of $4^1/_2$ per cent per year. Replacements due to death and retirement are about $2^1/_2$ per cent and growth probably will lie between 2 and $4^1/_2$ per cent, the lower figure being comparable to the population increase. Thus, it was established that the normal annual need for engineers should be from $4^1/_2$ to 7 per cent of the present number of 450,000, or roughly 20,250 to 31,500 per year. As not all graduates pursue engineering, the upper figure easily could be 40,000 graduates per year. It was further explained that current needs are more than twice the maximum long-term trends and educational institutions never can expect to meet large transient fluctuations.

Looking toward what might be done, Dean Eshbach first pointed out that the normal distribution curve of our population obtained by plotting accepted intelligence quotients, shows that less than 11 per cent of those in the high-school age group have an intelligence score above 125, which is comparable to the desired standard for admission to professional study. Considering the number who will attend high schools during the next 10 years, and the fact that less than 60 per cent of the male population is graduated from high school, the result is approximately 660,000 male graduates per year. Of that number only 200,000 can be considered good college material and less than 100,000 are adequately prepared to study science and engineering. Engineering would be represented by approximately one-third of the number in the major professions, and about one-seventh of the total number of all professionally engaged persons. Thus the present number of engineering freshmen, about 35,000, is the best expectancy of good talent which, with attrition, will provide only about 17,000 graduates. This is less than the minimum long-term needs and about one-fifth of the current demand for engineers. As remedial measures, Dean Eshbach suggested recognition of the greater needs for education and training on an intermediary technical level and the conservation of engineering talent strictly for engineering jobs. To do this, the educational system must anticipate the creation of more technical institutes and the public must de-emphasize the thought that a degree is the only socially acceptable terminal of education. He did not believe that much improvement in attrition can be expected for some time; most improvement in this direction will result from good counseling and better intellectual motivation in the home and the school. He also did not believe that much could be accomplished immediately by a campaign to interest present high school students in studying science and engineering as that probably would result in an increase in the attrition rate in college. He also spoke of the widespread feeling among parents and students that technical studies are narrowing and in their specialization too exacting in discipline. He pointed out that this intellectual laxity cannot be expected to produce an adequate supply of properly trained college freshmen for the needs of our future civilization. In conclusion, Dean Eshbach suggested a vigorous national campaign emphasizing the desirability of an elementary foundation in mathematics and science as a broad preparation for college study. This would not seriously hurt anyone's education and would give each high school student far greater flexibility in the choice of professional study. It also would mean that the counseling problem in high school must begin with the freshman class.

With respect to "A Program of Action for Local Sections," J. H. Foote noted the importance of Dean Eshbach's data that only 11 per cent of the high school students have an intelligence quotient of 125 or better; therefore, members in the Sections should not try to induce all the boys in the high schools to be engineers. Mr. Foote suggested reading and restudy of "Engineering—A Career, a Culture." He commented that many have the ability to tinker with manual dexterity but cannot get over the mathematical hurdle, and suggested that the profession look for boys on the farms and in rural areas. When talking about the profession, one must emphasize the engineering method of attack.

In respect to counseling, Mr. Foote dis-

(Above) Members attending the Summer General Meeting in Minneapolis visit an exhibit of old-time electric apparatus at the Hotel Nicollet. (Left) President McMillan, President-elect Quarles, and H. W. Meyer, chairman of the 50th Anniversary Committee, inspect some early types of lamps at the exhibit

cussed what is being done in a large city, a medium-sized city, and a small city. The Engineering Society of Detroit has been holding career days; cards are previously sent to the high school students who indicate their ideas and thoughts about engineering. A program is set up to tell the students what engineers do in the several fields: civil, mechanical, electrical, chemical, and so forth. The boys are assigned to counsellors who are prominent people and it has been found that personal contact is the most effective.

In Toledo, Ohio, a middle-sized city, ECPD does much the same as is done in Detroit, except that literature is sent out and the counselling is done in the high school.

In Jackson, Mich., a city of 70,000, two days are devoted to counselling, not only for engineering, but for the other professions such as medicine and law. The approach is made through the Chamber of Commerce. The schools are closed, and instead of counselling the boys in Jackson, the teachers are counselled. Teacher guests who come from small towns meet with the engineers of Commonwealth Services for an hour on a rotational basis; this is followed by a tour in which they are shown how business is done. The teachers are interested in the progress of their former students, and if industry is doing things well, the procedure is constructive. Mr. Foote suggested that the same thing might be done at the university level, with the engineering professors during the summers. The mutual exchange of ideas might be profitable.

SPECIFIC DISCUSSION

The guidance work which started in the New York area some 18 years ago with the five Founder Societies co-operating to give counselling was described by S. P. Shackleton, member of the ECPD Committee on Student Guidance. The approach in New York was made through the Board of Education, the Superintendent of Schools, and the principals. Meetings were highlighted by question and answer periods, after which there was an opportunity for personal interviews. Parent-Teacher Association meetings were not too successful as the parents sometimes tried to dominate the meetings. High schools in the nearby cities and all of the high schools in New York City take advantage of the services of the ECPD.

Mr. Shackleton also described a meeting with graduate educational forces in teachers colleges, where the opportunities and ways of presenting engineering careers to high school students was effectively discussed.

"The Ways in Which Publicity Can Help and How to Use It" were related by G. T. Minasian, chairman of the Public Relations Committee. He advocated a full and frank story, presenting the good along with the bad, as the best method of approach. Engineering culture—the unearthing of facts, evaluating them, and making decisions based upon them—is a wonderful training, regardless of whether one ultimately enters the engineering profession or not. Many executives today are engineers, thus, he cautioned against overselling an idea with too much grammar and too little willingness to work. In conclusion, Mr. Minasian urged that the importance of engineering work be emphasized through public relations, and that it also be emphasized that those who choose engineering as a career will never regret the training.

GENERAL DISCUSSION BY DELEGATES

In a general discussion of the shortage of engineers and counselling, the following views were expressed: L. H. Fox of Toledo supplemented the remarks of Mr. Foote. Concerning Louisiana, C. P. Noest told of the work of the Louisiana Engineering Society which is comprised of members of the Founder Societies. At the end of the school year a meeting on safety and agriculture is held, charts are employed, and the story is told of what engineering means, what engineers have to do, and the range of salaries. Approximately 2,500 students in 27 schools have career days and information is disseminated by means of the radio. J. C. Beckett of San Francisco explained that they were doing about the same as is done in Jackson. He raised the question of how to determine the effectiveness of the program or how many high school students are being channeled into engineering.

Elgin B. Robertson, AIEE Director, told of a highly successful banquet held in April and sponsored by the founder engineering societies in Dallas in co-operation with the Texas Society of Professional Engineers. The Banquet Committee was furnished, in advance, with the names and the chosen fields of higher education of the high school students and, in turn, a professional engineer from the chosen engineering field was assigned to each boy. Students were given the opportunity during the evening to discuss with their host subjects concerning their chosen field. The banquet was addressed by Dr. Houston, President of Rice Institute, regarding the historical aspects of engineering and opportunities for the future. The success of the meeting indicated that a similar program will be provided each year.

In response to the question previously raised, B. J. A. Skrotzki, chairman, Student Guidance, ECPD, explained that a rough index of the efficiency of guidance work is indicated by the fact that 18 years ago the attrition in engineering was about 62 per cent of those entering as freshmen, whereas today the rate has dropped to 50 per cent. Mr. Skrotzki cautioned against tying up guidance with the shortage of engineers, and pointed out that the welfare of the students should be the principal consideration. Engineers should not be counsellors; the counselling should be done by trained psychologists. It should be made clear that the intention is to supplement the high school counsellors and not supplant them. It also should be understood that such programs are not intended to do recruiting for industry, and that the main function of guidance work is to enable the individual student to evaluate his own abilities.

Professor Dow emphasized the importance of contacting an older brother, cousin, or friend because of greater stability, and J. L. Callahan, who has had many years of experience with students, pointed out that unless you have made contacts with the high school students you are missing some valuable experiences. Professor J. C. Clark of the University of Arizona expressed disbelief in the view that there is a growing laxity among students. He pointed out

(Above, left) A. E. Silver (right) receives the 1951 Lamme Medal from AIEE President F. O. McMillan during ceremonies at the Summer General Meeting in Minneapolis. (Above, right) President McMillan greets the incoming President for 1952–53, D. A. Quarles that it is quite common for fathers to insist that the coming generation is more lax than theirs. Thinking would be clarified if it would be remembered that engineering is a business. Professor Clark suggested as a definition: "The engineer is one who directs economic use of matter or energy."

In conclusion, President McMillan expressed his appreciation of the splendid discussion of this important subject, and his hope that all delegates would go home and see what might be done, but he cautioned that it would be a serious mistake to interest a high school student in engineering if he is not well qualified. He expressed the view that some secondary school programs are not healthy ones and that too often there is the attitude on the part of the secondary schools that a student's high school program does not make any difference when he gets to college. The tests which led to this conclusion were made with students who went through general colleges, not engineering schools. He suggested the delegates look into their high school programs and see if they have an adequate science program.

Section Delegates Discuss Management and Operation at Conference on Monday

The Section Delegates' Conference was held on Monday afternoon, following the forum on the shortage of engineers, with Vice-President C. S. Purnell, chairman of the Sections Committee, presiding. The order of business consisted of changes in Section organization, Institute affairs, Section operation and management, including the Section Growth Award presentation, a review of the revision of Section 85 of the Bylaws, and a general discussion by the delegates on various phases of Section operations. A comprehensive report of the Philadelphia Section for the year 1951–52 was distributed to the delegates; this is one of the largest Sections in the Institute and the report contained information on the membership finances, functions, and women's auxiliary meetings, as well as three regional conferences and a meeting of Student Consellors.

RIDGWAY SUBSECTION RECOMMENDED AS SECTION

The Ridgway Subsection is some 109 miles southeast of Erie, Pa., and it has grown from 35 to 60 members. On petition and approval to establish a new Section, the conference voted to recommend that the Ridgway Subsection be granted full active Section status. This will be the 96th Section of the Institute.

SECTION GROWTH AWARD PRESENTATION

After careful consideration of the growth of all Sections, Charles Clos, chairman of the Subcommittee on Section Growth Awards, announced the winners. All the Sections reports had not been received within 10 days after the meeting, and some Sections sent in all of their reports toward the end of the year. However, there was some improvement over the previous year and Chairman Clos congratulated the Sections. First place in the class of larger-than-average Section was awarded to the Maryland Section, while second place was awarded to the Milwaukee Section.

In the class of smaller-than-average Section, first place was awarded to the Louisville Section and second place was a tie between the Arkansas Section and Georgia Section.

For the administrative year 1951–52 in the class of larger-than-average Section, first place was awarded to the Toronto Section and second place to the Seattle Section. In the smaller-than-average Section class, first place was awarded to the Toledo Section and second place to the Syracuse Section.

A report of Section activities in the ninth District, prepared by R. E. Kistler, Vice-Chairman of Sections in the west, was distributed to the delegates. The report, which took into consideration a number of factors other than membership growth and meeting attendance, and included a table of comparative performance, was believed useful to the District Vice-President and should be of assistance to him toward directing additional effort where certain worth-while activities are lagging. Vice-President Purnell expressed the hope that similar reports would be prepared by all of the other Sections.

REVISION OF BYLAWS PERTAINING TO SECTIONS

Chairman Purnell drew attention to the resolution of the Board of Directors adopted at Providence, R. I., in April 1950 to eliminate all ex officio members from committees and reduce the committees to compact working groups so that they could function more efficiently. Section 85 of the Bylaws at present calls for the Section Committee to consist of five appointed members and the chairman of each Section ex officio. This Bylaw also calls for the Sections Committee to have general supervision and management of the Sections which is not consistent with present practice and the other Bylaws as the Sections are autonomous. Chairman Purnell appointed a special subcommittee consisting of J. E. Strasbourger, R. E. Kistler, H. A. Dambly, C. S. Purnell, and A. A. Johnson, to study the matter and to draw up suitable Bylaws to be sent to the Sections and the Committee on Constitution and Bylaws.

INSTITUTE FINANCES

The finances of the Institute for the year ending April 30, 1952, were reviewed briefly by W. J. Barrett, chairman of the Finance Committee. The adjusted excess of income over expenditures for the year just ended was $34,000 as compared with $13,000 for a year ago and $4,000 for the year ending 2 years previously. The total income was $983,000; about one-half of the gross income is paid by members and approximately 25 per cent of the income is derived from advertising. The total cost of *Electrical Engineering* was $321,000, with the advertising paying from 70 to 75 per cent of that cost. It is not necessarily desirable for the advertising to pay for the entire cost of the magazine. The expenses of the Section were $97,000, or about 10 per cent of the total expenses of the Institute.

Attention was drawn by Mr. Barrett to the fact that the Engineering Societies Building is obsolete, and that it had been considered so in 1921. Recently a number of offers have been received for the building and land of approximately $900,000. He drew attention to the resolution of the Board of Directors adopted on April 17, which requested that the United Engineering Trustees (UET) be urged to consider promptly and to submit to the other Founder Societies a plan for raising the additional funds required over and above the assets of the UET available for the purpose by means of contributions from the reserve funds of the Founder Societies and other engineering societies that might join for the purchase of a new building, sometimes described as a new Engineering Center. It had been estimated that the cost of a new building for the four Founder Societies, and others, would be approximately $5,000,000 (*EE, Jul '52, p 664*). The depreciation and renewal reserve fund of UET is approximately $820,000, and with this added to a $900,000 sale price for the present building and land, the UET available assets would be about $1,750,000. The June market value of the AIEE's reserve capital funds was $687,000; if the Institute would devote half of this reserve fund toward a new building it would contribute about a third of a million dollars. Likewise, if each of the Founder Societies was to devote sums from the capital reserve funds, it should be possible to add $2,500,000 to $3,000,000 toward the project which, together with the funds from any other society that might be interested, would leave but a small gap to be financed.

UNITY OF THE ENGINEERING PROFESSION

A brief report on the status of the unity of the engineering profession was presented to the delegates by President McMillan. The Exploratory Group to Consider the Increased Unity of the Engineering Profession prepared two reports; the first, in December 1950, outlined four plans, *A*, *B*, *C*, and *D*, of organization for discussion purposes. This report was submitted to the Sections and $7^1/_2$ Sections favored Plan *A*, none favored Plan *B*, $25^1/_2$ favored Plan *C*, and 9 favored Plan *D*. Three Sections favored no unity at all and two others stated they had no preference. The exploratory group submitted another report to Engineers Joint Council (EJC) in December 1951 (*EE, Jul '52, pp 588–94*). The Board of Directors unanimously rejected this plan because the majority of members had indicated the desirability of a unity organization somewhat along the lines of Plan *C* with provision for individual membership. There was also apprehension in regard to the report of the exploratory group with reference to the limit of three representatives on EJC for the larger societies; also, no provision was made for financing to carry on after the new organization is set up. The Board of Directors further considered the matter at its April 17 meeting and reaffirmed its former position.

The proposal that all the engineering societies prepare a survey form to be presented through the several societies was not accepted by EJC on the day following the AIEE Board of Directors meeting. The matter was discussed at a meeting on Monday evening, and was considered further at the meeting of the Board of Directors on Thursday, June 26.

GENERAL DISCUSSION BY DELEGATES

The general discussion by delegates on various phases of Section activities, membership, Student member cards, publicity, co-operation with other professional societies, Subsections, women's auxiliaries, and increasing meeting attendance, as well as the use of model Bylaws, resulted in a profitable exchange of ideas.

MEMBERSHIP

The discussion on membership was opened by Charles Clos, vice-chairman of the Membership Committee, who explained that the committee had been reorganized to function more effectively. If people are interested in becoming members, Mr. Clos suggested that one should not try to sell the Institute, but should give the prospective applicants the means whereby they can join, the membership application booklet and an application blank.

Strong feeling was expressed by several of the delegates to the effect that the constitutional requirements for Fellow grade are too rigorous. Views also were expressed that the $15 dues for the new Affiliate grade, as contrasted with the $10 dues for the Associate grade, made the new Affiliate grade unattractive. It was also pointed out that there are some very excellent prospects being graduated from non-accredited colleges.

Vice-President Norris explained the purpose of the Student member card records and several of the delegates expressed the desire to receive the filled-out cards promptly. Director D. D. Ewing explained the difficulties of getting the cards filled out by students in a large school, whereas for the smaller schools it is not so difficult.

PUBLICITY

G. T. Minasian, chairman of the Public Relations Committee, explained that a new publicity kit has been prepared and will be sent to the publicity chairmen of the Sections, or, in the absence of a publicity chairman, to the chairman of the Section. Mr. Minasian appealed to the delegates for ideas and information for the publicity news letter which will be issued as often as necessary. Chairman Purnell drew attention to the fact that newsworthy items of Section activities for publication in *Electrical Engineering* should be sent to the editor by the 25th of the second month preceding the date of issue; for example, by June 25 for the August issue, by July 25 for the September issue.

CO-OPERATION WITH OTHER SOCIETIES

The matter of joint co-operation with other societies was presented by W. J. Barrett, a member of the Joint AIEE–Institute of Radio Engineers Co-ordination Committee, which is a committee at the national, or board, level. He explained that the AIEE is in the field of communication and radio and that it is our policy to recognize technical advances in these fields. The two Institutes are not regarded as competitive and it is the policy to think co-operatively on matters in every way possible. Attention was drawn to successful joint sessions, joint meetings, and conferences, as well as the joint AIEE-IRE student branches, and Mr. Barrett urged that the Sections give willing and hardy co-operation to joint activities. Out of these joint activities there might arise occasions for joint publication. A few have looked forward to the day when the two societies might merge, and if co-operative activities develop extensively they might naturally lead to eventual consolidation.

SUBSECTIONS

It was reported that there will be 50 Subsections as three or four more are now under consideration. Areas which can be served better locally are logical choices for Subsections and it does not take many members to start them. Chairman Purnell suggested that the Section officers visit and meet with the Subsections and counsel them wherever possible. One Section reported a feeling of responsibility to provide good programs for the Subsections, and the Maryland Section reported arranging for speakers which would also address the Subsection on the following night.

WOMEN'S AUXILIARIES

The successful operation of the Women's Auxiliary founded in 1947 in the Philadelphia Section was described by H. H. Sheppard, Section Chairman. The Section originally appropriated but $25 for this activity; the auxiliary now has grown to 107 members and has conducted book reviews, studies of antiques, and so forth. The Women's Auxiliary has fostered a more friendly feeling with competitors and, in some cases, resulted in new members.

The Lynn Section reported that they do not have a Women's Auxiliary, but that they operate in much the same manner since they have many women employees who assist with arrangements for meetings.

USE OF MODEL BYLAWS

In respect to the use of Model Bylaws in Section organization, Chairman Purnell suggested that they should be read and studied with a view toward serving as a guide from which the Sections can draw up a set of their own bylaws.

LOCAL ENGINEERING COUNCILS

In introducing this subject, Chairman Purnell suggested that the local engineering councils serve as a good basis from which student guidance can be evolved.

The Council of Technical and Scientific Societies in Albuquerque, N. Mex., was described by Dr. H. C. Briggs, Northern New Mexico Section. President-elect D. A. Quarles addressed the Council of Technical and Scientific Societies in Albuquerque on May 12 (*EE, Jul '52, p 665*).

INCREASING MEETING ATTENDANCE

Several good ideas for increasing meeting attendance and fellowship arose in an exchange of experiences on this subject. The Seattle Section reported the use of lapel cards coupled with the keeping of a record of the names, so that at the conclusion of a meeting the Section has a file on all who had attended. Several Sections advocated starting membership campaigns early, but one Section suggested beginning with a smoker from which names are obtained for the start of the membership campaign at the first meeting. In the St. Louis Section a fellowship committee contacts prospective members in the industries. The Spokane Section, which has a scattered membership, reported success on holding the meetings on Friday evenings.

Summer Meeting Technical Sessions Cover Wide Range of Institute Activities

A total of 38 technical sessions and conferences were held during the 5 days of the Summer General Meeting. The subject matter presented ranged through the whole gamut of Institute activities in six broad divisions. In addition, two sessions were held in which the winners of the District Branch Prize Papers presented their papers. This was made possible by the grant from the Members-for-Life Fund.

ELECTRICAL TECHNIQUES IN MEDICINE

Two sessions, which were of great interest to members, dealt with electrical techniques in medicine. The afternoon session was held jointly with the Safety Committee. E. D. Trout, General Electric Company of Milwaukee, presided over the morning session and Dr. S. R. Warren, Jr., University of Pennsylvania, was chairman of the second session.

Dr. R. E. De Forest, American Medical Association, read a paper on the factors concerned with the medical application of ultrasound in which he brought out that sound waves at 800 kc raised the temperature of bone structure of an experimental animal better than microwave electric energy. He explained the ultrasonic transducer which, powered by a quartz crystal oscillator, transmits the energy either directly to the patient's body or is applied through water.

Dr. H. D. Bouman and Kathryn J. Shaffer, University of Wisconsin, presented their findings on the electrical stimulation of human muscle and D. A. Kohl, University of Minnesota, explained the functioning and uses of the electrokymograph, which records graphically the passage of X rays through body tissue. This can be used to measure the dilation of the heart, the amount of blood passing through the lungs, and so forth, without using dangerous dosages of X rays due to the photomultiplier tube in the instrument.

Dr. F. T. Jung, American Medical Association, told about the work of the committee which he heads in their acceptance or rejection of physical therapeutic machines, medical electric equipment, and similar apparatus.

Dr. W. B. Kouwenhoven, The Johns Hopkins University, presented a progress report on his investigations of the heart in fibrillation and the electrical means used in defibrillation.

The physiologic effects of microwaves were explained by Dr. J. F. Herrick and Dr.

Shown here are members of this year's General Meeting Committee for the Summer Meeting in Minneapolis. Front row, left to right, are: J. R. North, G. B. Germain, Mrs. H. E. Hartig, R. R. Herrmann, Byron Clingerman, R. M. Kalb, H. P. Bruncke, R. G. Lynn, E. H. Hagensick, H. E. Hartig. Back row, left to right: P. G. Bowman, Edward Willson, R. B. Witrud, Lincoln Rietow, R. H. Olson, A. H. Hendry, E. A. Wold, P. A. Cartwright, H. E. McWethy, W. H. Gille, Max Risley

F. H. Krusen, Mayo Clinic. Using a frequency of 3,000 megacycles, it was found that the temperature of tissue increased for about 20 minutes and after that, there was no further increase; however, the blood flow increased, which is nature's way of ridding a particular part of the body of too much heat.

In the last paper of the afternoon session, Dr. H. M. Hines and J. F. Randall, University of Iowa, told about possible industrial hazards in the use of microwave radiations. The change in temperature seems to be the cause of injuries and certain portions of the body, such as the stomach, gall bladder, and so forth, are particularly vulnerable. It was also found that cataracts resulted in animals' eyes when use of microwaves caused a great temperature rise.

PROFESSIONAL DIVISION

The Committee on Management sponsored a session which dealt with the management of engineering activity followed by a panel discussion with W. R. Hough as moderator. Three papers were presented. The first paper, by T. M. Linville of the General Electric Company, treated the techniques for managing engineering work. The second paper was presented by C. L. Brisley of the Wolverine Tube Company and dealt with work simplification as applied to engineering work. This study is related to the engineering manpower shortage. The author first drew on the experiences from a study in the nursing field where there has been a shortage of trained nurses for some time. The theory of probability was demonstrated and applied to the study made of engineering work. The third paper, by E. W. Seager, Cutler-Hammer Corporation, outlined the important factors to take into consideration in the training for engineering supervisors.

SAFETY

In a session on safety the central station point of view was presented in two papers; one dealt with the engineers' stake in safety, the other treated the extinguishing of fires in electric equipment. Another paper discussed the safety aspects of grounding portable equipment, and still another, from the industrial point of view, considered the electrical aspects of mine safety. The committee also participated jointly in another session on safety and electrical techniques in medicine.

COMMUNICATION DIVISION

In a symposium, four epoch-making papers were presented which had to do with nation-wide toll dialing. This session was sponsored by the Communication Switching Systems Committee with John Meszar presiding. The intricacies of this extensive telephone service, the fundamental plans for toll telephone plants, nation-wide numbering, and the switching systems involved were presented by prominent authors in the field of communications.

GENERAL APPLICATIONS DIVISION

The Committee on Land Transportation sponsored a session in which three papers were presented. The story of 15 years' progress in the design of industrial diesel-electric switchers was given by R. W. Barrell of the General Electric Company, the electrification of Holland's railway systems was described by A. H. Candee of the Westinghouse Electric Corporation, and a conference paper by C. M. Hines of the same company was entitled "Get Off the Beaten Path."

INDUSTRY DIVISION

In this field two sessions on feedback control systems were held; the first dealt with the problems of nonlinearities in feedback control systems, and the second session embraced a variety of subject matter, such as the analysis of sampled data systems, signal component control, stability limits for third-order servomechanisms, a progress report on terminology and nomenclature, and stabilization templates for servomechanisms.

In a session on industrial power systems the subjects of electric power relaying in industrial plants, the philosophy of electrical designs for the office building of tomorrow, and the response of industry to systems neutral grounding and higher voltage lighting were discussed. Arc furnaces and the melting and refining of modern steels were discussed in a session on electrothermal processes. Another session on electrostatic processes had to do with high-voltage power supply for electrostatic precipitation, constant-current control for industrial precipitators, and the electrostatic atomization and precipitation of coating materials. Other sessions in the industry division dealt with the mining industry and storage batteries.

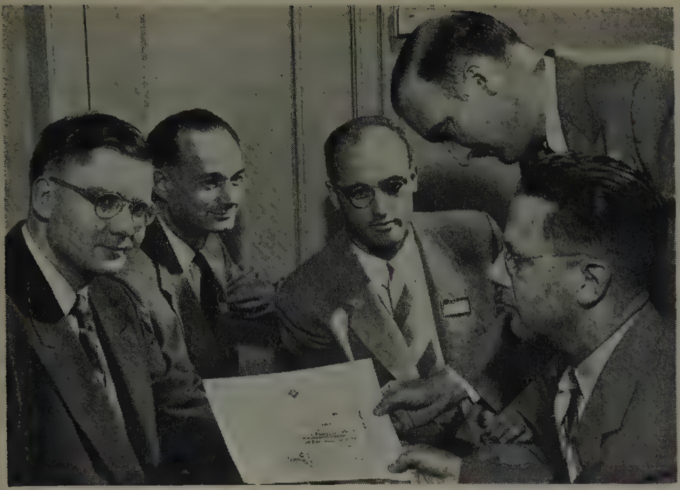
SCIENCE AND ELECTRONICS DIVISION

In this division, a total of 12 sessions were held. Two sessions each presented a variety of subject matter in the fields of instruments and measurements, basic sciences, electrical techniques in medicine, magnetic amplifier circuits, and magnetic amplifier test methods. Other sessions dealt with computing devices, new electronic devices and applications, and dielectrics. In the latter session three important papers had to do with the properties and applications of fluorine and two others treated the impulse dielectric strength characteristics of liquid-impregnated pressboard and the variation at constant density of the dielectric breakdown of paper with air resistance.

A microhygrometer, installed in a hypodermic needle and used to determine the moisture content of food stuff in storage or in processing, was described by W. A. Brastad, General Mills, Inc. The resistance of the probe varies with the percentage of moisture and so permits a closer control to be maintained than heretofore possible. Another conference paper on control given in the Tuesday afternoon session on instruments and measurements was by John Wilson, Minneapolis-Honeywell Regulator Company, on a new type of home-heating control whereby several temperature-sensing units on inner and outer walls of a house provide improved control of the interior.

A much discussed paper, "Influence of Atmosphere Upon Contact Transients in a Simple Electric Circuit," by O. E. Berg and H. E. Strauss, Naval Research Laboratory, was given in the Wednesday morning session on basic sciences, over which M. G. Malti, Cornell University, presided. A. D. Moore, University of Michigan, explained a new property of 2-dimensional fields as illustrated on fluid mappers.

Three conference papers were presented at the session devoted to new electronic devices and applications, at which W. C. White, General Electric Company, presided, and which was held on Friday morning.



Richard F. Grantges (left), District Branch First Prize winner, receives his award certificate from J. R. North (right), chairman of the Prize Awards Committee, at the recent Summer General Meeting. Looking on are, left to right, S. C. Killian, F. D. Olney, Jr., and Professor P. A. Cartwright

The first paper, "An Engineering Progress Report on Reliable Tubes," was presented by R. E. Moe, General Electric Company. About a dozen tube types were redesigned in order to eliminate some of the inherent weaknesses. A 50-hour burn-in period was established to catch early failures with the result that 95 per cent survived instead of the usual 80 per cent. By using the new tubes, organizations which use equipment with many tubes have effected a substantial saving.

Dr. E. D. Cook, General Electric Company, told about recent advances in industrial electronics and how by the resulting increase in efficiency, companies were able to save sufficiently to offset partially increases in other operating expenses.

D. S. Peck, Bell Telephone Laboratories, described the new 10-stage cold-cathode stepping tube, in which the discharge travels along the series of cathodes, and demonstrated its functioning.

POWER DIVISION

In the power division a total of 15 sessions were held; three in the field of transmission and distribution, one each in the fields of switchgear and relays, two on rotating machinery, and a third which was related to insulation testing and temperature standards for the electric insulation of rotating machinery. Still other sessions were on the subjects of carrier current, insulated conductors, system engineering, excitation systems, and hydroelectric systems. In the last-named session, the Holcombe Hydro Plant of the Northern States Power Company was described by H. E. Rhoades who also discussed the control and operational features in relation to the other plants on the Chippawa River. This session was an innovation in the form of a round-table discussion where prepared answers were given to questions sent in prior to the meeting, as well as answers to questions which arose from the floor.

District 2 Holds Student Prize Paper Competition

The Joint AIEE–Institute of Radio Engineers Student Branch at Pennsylvania State College was host to the District 2 (Middle Eastern) Student Prize Paper Competition, May 2–3, 1952. Twelve papers were presented and the following prizes were awarded:

1. District Student Paper Prize: John V. Reihing, Jr., University of Pittsburgh, for the paper entitled "Magnetic Fluids."
2. Second-place winner was: Joseph Y. F. Ng, Carnegie Institute of Technology, for the paper entitled "Aircraft Ignition Trouble-Shooting With the Engine Analyzer."
3. Third-place winner was: Donald J. Glick, Lehigh University, for the paper entitled "A New Proof of the Fisher-Hinnon Method of Harmonic Analysis."

The District Student Paper Prize consists of $25 in cash, a certificate, and a travel allowance to the Summer General Meeting in Minneapolis, Minn. The winner was also invited to the David Sarnoff Research Center at Princeton, N. J., at the expense of the RCA Laboratories Division. Second- and third-place winners also received an expense-free trip to the Research Center at Princeton.

The winner of the best question prize of $5 was Thomas E. Gilligan of Villanova College, and the winner of the next best question prize of $3 was Lowell R. Dibble of Ohio Northern University.

A dinner was held on Friday evening which was addressed by Dean E. B. Stavely, who discussed "One Engineer's Scrapbook." On the following day an inspection trip was taken to the Garfield Thomas Water Tunnel.

Participants in the Student Prize Paper Competition sponsored by the AIEE Middle Eastern District (2). Shown at front, center, is Vice-President J. C. Strasbourger

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Are You Responsible for Electrical Safety?

If, in your work, you are directly concerned with electrical safety, the AIEE Committee on Safety would be glad to add your name to their special mailing list.

Many times the Safety Committee has information that would be of help to AIEE members responsible for electrical safety, who may not be on our present mailing list. Also, sometimes the committee needs the composite guidance and advice of a group of engineers who are experienced in certain aspects of safety. The more members whom we know to have a stake in electrical safety, the better the committee can serve the Institute.

If you would like to be added to our special mailing list, send your name to: G. W. Elg, Consolidated Edison Company of New York, Inc., 4 Irving Place, New York 3, N. Y.

AIEE Committee on Safety

Middle Eastern District to Meet in Toledo, Ohio

Toledo, Ohio, will be host this year to the AIEE Middle Eastern District Meeting to be held in the Commodore Perry Hotel, October 28–30, 1952.

Technical sessions will be held on the following subjects: glass industry, rotating machinery, industrial controls, power, and electric equipment in the automotive industry. A special session on "management" will be of interest to all, and inspection trips have been planned to several of Toledo's widely diversified industries.

Members of the Middle Eastern District Meeting Committee are: M. W. Keck, *Chairman;* C. E. Ide, *Honorary Chairman;* T. J. Kozak, *Member at Large;* J. W. Cofer, *Technical Program;* D. L. Rexford, *Registration and Finance;* W. E. Borub, *Entertainment;* J. B. Cloer, *Publicity;* R. Stott, Jr., *Secretary-Treasurer;* L. E. Smith, *Scheduling;* W. H. Schwalbert, *Special Meetings and Inspection Trips.*

New Orleans—Site of Fall Meeting

Aerial view of the Mississippi River at New Orleans, La., where the AIEE Fall General Meeting will be held October 13–17, 1952. Most of the city lies in the 9-mile crescent in the foreground, hence the designation, "Crescent City." The bridge at the center is the Huey P. Long Bridge, a railway-automobile bridge 4.4 miles long

Sharon Section Holds Dinner Meeting

Approximately 200 persons attended the annual dinner meeting of the AIEE Sharon (Pa.) Section on June 4, 1952. During the meeting, M. Morisuye, outgoing chairman, reviewed the activities of the past year and introduced the new officers of the Sharon Section and the newly formed Youngstown (Ohio) Subsection. Shown here are, front row, left to right: J. H. Shep, Jr., Secretary-Treasurer, Youngstown Subsection; T. A. Casey, Chairman, Sharon Section; Nathaniel Leverone, speaker of the evening and founder and chairman of the board, Automatic Canteen Company of America, who discussed "This Freedom of Ours"; Mr. Morisuye; W. D. Albright and G. J. Hattrup, members of the Executive Committee. Back row, left to right: L. J. Besch, Secretary-Treasurer, Sharon Section; E. A. Mort, Chairman, Youngstown Subsection; E. C. Wentz, Vice-Chairman, Sharon Section

Machine Tool Conference Scheduled for October

The fifth annual AIEE Machine Tool Conference will be held in Albany, N. Y., October 29–31, 1952. Headquarters will be at the Hotel Ten Eyck. This conference, sponsored annually by the AIEE Machine Tool Subcommittee, should prove of interest to all engineers interested in machine tool electrification.

Host for this year's meeting will be the AIEE Schenectady Section. Additional information can be obtained from J. M. Delfs, Chairman, AIEE Machine Tool Subcommittee, in care of the General Electric Company, Schenectady, N. Y.

1953 Winter Meeting Committee. According to a recent announcement, the following have been appointed as members of the general committee to make plans for the Winter General Meeting, to be held at the Hotel Statler, New York, N. Y., January 19–23, 1953: C. T. Hatcher, Chairman; A. J. Cooper, Vice-Chairman; J. J. Anderson, Secretary; W. J. Barrett, Budget Coordinator; M. D. Hooven, Vice-President, District 3, 1952–53; L. F. Hickernell, Technical Program (Chairman, Committee on Technical Operations); G. T. Minasian, Publicity (Chairman, Committee on Public Relations); J. A. Parrott, General Session (Chairman, New York Section); J. B. Harris, Jr., Philadelphia Representative.

Recording, Controlling Instruments to Provide Conference Subject

The AIEE Subcommittee on Electrically Operated Recording and Controlling Instruments is planning a 2-day special technical conference for Philadelphia, Pa., on November 17 and 18, 1952. The conference will be held at the Benjamin Franklin Hotel.

The purpose of the special technical conference is to educate and stimulate interest in the design, theory of operation, and application of electrically operated recording and controlling instruments. The conference is meant also to familiarize engineers with the recent advances in the metering and control of industrial processes, advances which largely have been made possible by the utilization of new electric recording and controlling techniques.

Further information may be obtained by writing to: G. L. Broomell, in care of the Leeds and Northrup Company, 4901 Stenton Avenue, Philadelphia 44, Pa.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Note. Because of the changeover in committee personnel, no items on committee activities are included in this issue.

Cleveland Section Motor and Controls Group

Members of the Motor and Controls Group of the AIEE Cleveland Section gathered at the American Airlines' Hangar on April 1, 1952, for a meeting and tour of the American Airlines Convair Flagship. The group heard an interesting discussion of the Convair's electric system

AIEE PERSONALITIES.....

S. B. Williams (M '37), director of public relations, Sylvania Electric Products Inc., New York, N. Y., has been appointed assistant to the president. Mr. Williams joined the staff of *Electrical World* in 1914 and in 1920 became assistant managing editor. Two years later he was appointed editor of *Electrical Record* and in 1924 became manager and editor of *The Electragist.* In 1928 he was appointed general manager and editor of *Electrical Contracting*, and in 1936 became managing editor of *Electrical World*, serving as editor of that magazine from 1937 to 1947. He joined Sylvania in 1947 as manager of customer relations of the Lighting Division and became director of public relations 2 years later. He served as president of the Illuminating Engineering Society in 1944 and 1945. He has served the AIEE on the following committees: Publication (1939–44) and Lamme Medal (1941–44, Chairman 1942–44).

E. C. D. Molina (M '22, F '51), special lecturer in mathematics, Newark (N. J.) College of Engineering, has been awarded the honorary degree of doctor of science by Newark College of Engineering. A native of New York City, Mr. Molina joined the Western Electric Company in 1898 and then transferred to the engineering department of the American Telephone and Telegraph Company in Boston, Mass. Transferred to New York in 1907, he continued with American Telephone and Telegraph and later with the Bell Telephone Laboratories as switching theory engineer. His contributions in translating system pulses contributed largely to the development of the dial telephone of today. Following his retirement from the Bell Laboratories in 1942, he joined the staff of the Columbia University War Research Division and in 1945 went to Newark College of Engineering. He is a fellow of the Royal Economic Society and a member of the American Mathematical Society, the American Astronomical Society, American Statistical Association, and other professional groups.

A. E. Maibauer (AM '31), development engineer, Bakelite Company, a division of the Union Carbide and Carbon Corporation, New York, N. Y., has been appointed assistant to the manager of the New York Sales Development Group. Mr. Maibauer was graduated from The Cooper Union in 1925 and joined the Bakelite Company in the Physical Testing Department of their Bloomfield, N. J., plant. He joined Bakelite's Sales Development Group in 1945. He is a member of the American Chemical Society and the American Society of Naval Engineers.

G. S. Brown (AM '33, F '50), professor of electrical engineering, Massachusetts Institute of Technology, Cambridge, has been appointed Head of the Department of Electrical Engineering. Born in Drummoyne, New South Wales, Australia, on August 30, 1907, Dr. Brown studied at the Melbourne Technical School and then served as a junior engineer with the State Electricity Commission of Victoria, Australia, from 1926 to 1929. He was graduated from Massachusetts Institute of Technology with the degrees of bachelor of science, master of science, and doctor of science in 1931, 1934, and 1938, respectively. He was named research assistant in the department of electrical engineering in 1931, instructor in 1932, assistant professor in 1939, associate professor in 1941, and full professor in 1946. Dr. Brown has been Director of the Servomechanisms Laboratory since its foundation in 1941 and was appointed associate head of the electrical engineering department in 1950. In recognition of his services to the country, Dr. Brown was awarded the President's Certificate of Merit, the nation's second highest civilian award, in October 1948. He is also a director of the Ultrasonic Corporation, Cambridge. He is a fellow of the American Academy of Arts and Sciences and a member of the American Society for Engineering Education, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu. An active member of the AIEE, Dr. Brown has served the Institute on the following committees: Industrial Control (1946–52), Instruments and Measurements (1947–50), Feedback Control Systems (1949–52, Chairman 1949–50), Technical Program (1949–50), Standards (1949–52), Industry Co-ordinating (1949–50), and Award of Institute Prizes (1950–52).

F. W. Godsey, Jr. (AM '30, F '45), manager of the electronics, X-ray, and air-arm divisions; **L. A. Kilgore** (AM '29, F '45), assistant manager, alternating current generator engineering, transportation and generator division; **J. D. Miner, Jr.** (M '42, F '49), manager of aviation engineering, small motor division; **O. O. Rae** (AM '26), southeastern district manager; **J. B. Seastone** (M '46), manager, materials engineering; and **C. E. Valentine** (AM '27, M '41), manager, design section, generator voltage regulators, have been awarded the Westinghouse Order of Merit, highest company award for distinguished service, by the Westinghouse Electric Corporation, Pittsburgh, Pa. The awards were presented in New York, N. Y., on June 25, 1952. Citations paid tribute to the men for outstanding accomplishments in the design and development of electric apparatus, manufacturing machinery and techniques, equipment to meet special or unusual conditions or applications, new materials and alloys, or for distinguished leadership in executive, administrative, or engineering fields.

F. S. Bacon, Jr. (AM '37, M '44), assistant general sales manager, Rockbestos Products Corporation, New Haven, Conn., has been named general sales manager of The Gamewell Company, Newton Upper Falls, Mass. Mr. Bacon is a member and past-president of the Massachusetts Society of Professional Engineers and has served the AIEE on the following committees: Membership (1944–49) and Industrial Power Applications (1944–45).

L. F. Hickernell (AM '25, F '34), chief engineer; **D. E. Allen** (AM '23), sales manager; and **R. B. Steinmetz** (AM '26, M '48) general manager of mills, have been named members of a recently formed Research and Development Committee of the Anaconda Wire and Cable Company, Hastings-on-Hudson, N. Y.

P. L. Howard (M '50), electrochemist, National Bureau of Standards, Washington, D. C., has joined the Yardney Electric Corporation, New York, N. Y., as technical director. Dr. Howard headed the United States Navy's battery development program during World War II and was consultant on batteries to the Atomic Energy Commission. He organized the Washington Section of the Electrochemical Society and is a member of the American Chemical Society.

F. L. Magee (AM '20), vice-president and general production manager, Aluminum Company of America, Pittsburgh, Pa., has been elected a director of the company. Mr. Magee joined the Aluminum Company of America in 1917, following his graduation from Lehigh University. In September 1943 Mr. Magee was made general production manager, and in November 1946 he was named a vice-president.

A. H. Lamb (AM '35, M '44), Vice-President, Weston Electrical Instrument Corporation, Newark, N. J., has been named the outstanding Newark College of Engineering alumnus of the year by the college board of trustees. Mr. Lamb was graduated from Newark College of Engineering in 1930 with a degree in electrical engineering. He has been associated with the Weston Corporation since 1924. Mr. Lamb has over 100 inventions to his credit and received a citation from the United States Navy for development of technical and scientific weapons. He is a member of the National Society of Professional Engineers.

S. J. Powers (M '51), manager of the Selenium-Intelin Division, Federal Telephone and Radio Corporation, Clifton-Passaic, N. J., has been elected a vice-president of the corporation. A native of New York City, he received his bachelor of science degree in electrical engineering from The Cooper Union School of Science in 1928. He has been with the company since 1934 and was named head of the Selenium-Intelin Division in 1947. Mr. Powers is a member of the Institute of Radio Engineers.

A. B. Du Mont (F '43), President, Allen B. Du Mont Laboratories, Inc., Clifton, N. J., has been made a Chevalier of the Legion of Honor by the French Government. The honor was conferred on Dr. Du Mont by Jean de Lagarde, Consul-General in New York City, on May 22, 1952. The rank was bestowed in recognition of the outstanding service rendered to the Allied cause during World War II through his scientific work, and for his contributions to commercial relations between the United States and France.

N. J. Corwin (AM '48), general foreman, I&T Tube Division, General Electric Company, Schenectady, N. Y., has been appointed manager of the company's Scranton, Pa., Tube Works. Mr. Corwin has been associated with General Electric since 1937, and for the past 12 years has held various supervisory manufacturing assignments. He is a member of the Institute of Radio Engineers and the National Society of Professional Engineers.

Reinhold Rudenberg (M '38, F '50), Gordon McKay Professor of Electrical Engineering, Harvard University, Cambridge, Mass., has been invited to deliver a series of lectures on modern topics in electrical engineering at the University of Rio de Janeiro and the University of Sao Paulo in Brazil, and the University of Montevideo in Uruguay.

W. W. Sproul (AM '42), sales manager, industrial products divisions, Westinghouse Electric Corporation, Pittsburgh, Pa., has been named Vice-President in charge of the industrial products divisions. Mr. Sproul was graduated from Virginia Polytechnic Institute in 1927, and joined the company that same year. He was assigned to the sales department in the transformer division after completing the graduate training course, in 1944 became sales manager for that division, and in 1949 he became sales manager for all industrial products.

M. I. Alimansky (AM '45, M '50), manager of engineering, Distribution Transformer Department, General Electric Company, Pittsfield, Mass., has been appointed a member of the Massachusetts Board of Registration of Professional Engineers and Land Surveyors. The Massachusetts Board of Registration consists of five members representing specific engineering fields. Mr. Alimansky will represent the electrical field.

W. T. Anderson (AM '44, M '50), assistant professor, Michigan College of Mining and Technology, Houghton, and **E. S. Huff** (AM '49), electrothermal engineer, United States Bureau of Mines, Norris, Tenn., have joined the staff of the Gaseous Diffusion Plant, Oak Ridge, Tenn.

W. L. Wearly (AM '38), Vice-President, Joy Manufacturing Company, Pittsburgh, Pa., has been elected General Sales Vice-President. Mr. Wearly joined the Engineering Department of the company in 1937 and has served successively as service manager and Vice-President.

R. T. Fenn (AM '47), electrical engineer, Bryant Chucking Grinder Company, Springfield, Vt., has joined the Sterling Engineering Corporation, Winsted, Conn., as chief engineer.

V. L. Moffett (AM '49), erection engineer, Allis-Chalmers Manufacturing Company, Angola, Ind., has been appointed an engineer at the Gaseous Diffusion Plant of the Atomic Energy installation at Oak Ridge, Tenn.

T. E. Meyers (AM '51), electrical engineer, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been assigned as a sales representative to the Los Angeles, Calif., district office of the company's general machinery division.

B. E. McArthur (AM '45), chief engineer, Magnethermic Corporation, Youngstown, Ohio, has been appointed Vice-President in charge of engineering.

A. P. Davis (AM '19), Director, Arma Corporation, Brooklyn, N. Y., has been elected President of the corporation. Mr. Davis had held the post previously but retired from the position in 1947. Mr. Davis helped found the Arma Corporation in 1918.

J. A. Hartman, Jr. (AM '51), sales engineer, Winkle Electric Company, Youngstown, Ohio, has joined the Magnethermic Corporation, Youngstown, as sales engineer.

J. F. Potts, Jr. (AM '49), electrical engineer, Tennessee Valley Authority, Chattanooga, has been appointed to the staff of the Oak Ridge National Laboratory, Oak Ridge, Tenn.

E. J. Doyle (M '30), President, Commonwealth Edison Company, Chicago, Ill., has been given an honorary doctor of laws degree by the University of Notre Dame.

OBITUARY • • • •

Leo Hayes Cleary (AM '20, M '26, F '42), consulting engineer, Washington, D. C., died on May 3, 1952. He was born in Waterbury, Conn., November 24, 1894, and was graduated from the Catholic University of America in 1916 with a bachelor of science degree in electrical engineering. After a year of experience with general contracting firms in New York and Connecticut, he became associated with F. R. Weller, a Washington consulting engineer engaged in the design of power plants for the United States Navy Bureau of Yards and Docks. From 1919 to 1922 he was employed by the Bureau of Yards and Docks in the design of electric distribution systems for shore establishments. Leaving government service in 1922, he was for 8 years associated with Washington engineering and contracting firms on a variety of projects. In 1930 he opened his own office as an independent consultant and served as a designer or consultant on such projects as the Williamsburg (Va.) Restoration, Capitol Power Plant, and House and Senate Office Buildings. He was secretary of the District of Columbia Board of Registration of Professional Engineers and a code consultant to the National Electrical Contractors Association. He was a member of the Illuminating Engineering Society and the National Society of Professional Engineers. He served the AIEE on the Committee for Registration of Engineers (1949–50).

Samuel Stuart Mackeown (AM '27, M '34), professor, California Institute of Technology, Pasadena, died on May 29, 1952. Dr. Mackeown was born in New York, N. Y., on December 3, 1895, and was graduated from Cornell University in 1917. During World War I he served as an assistant physicist in the research division of the United States Bureau of Standards at Washington, D. C. He became an assistant professor in electrical engineering at California Institute of Technology in 1926, an associate professor in 1929, and a full professor in 1941. He served as a lieutenant commander in the United States

Naval Reserve in the radio development section during World War II. Dr. Mackeown also served at various times as a consulting engineer and patent expert for the General Electric Company, the American Telephone and Telegraph Company, Metro-Goldwyn-Mayer, and the Standard Oil Company. He was a member of the Institute of Radio Engineers, Sigma Xi, and Tau Beta Pi. He served the Institute on the following committees: Electrophysics, Basic Sciences (1931–33, 1940–41); and Communication (1938–41).

George Nathan Tidd (AM '00, Member for Life), retired, former Chairman of the Board of the American Gas and Electric Company, New York, N. Y., died June 17, 1952. Born in Barclay, Pa., January 16, 1874, he began his career as a telegraph operator. Switching from telegraphy to electric power, he became manager of the Waverly and Sayre Electric Company of Waverly, N. Y., and went on to the managership of the Beacon Light Company, Chester, Pa. In 1904 he was named manager of the Marion (Ind.) Light and Power Company and later also managed the Muncie (Ind.) Electric Light Company. Mr. Tidd went to the Scranton (Pa.) Electric Company, a subsidiary of the American Gas and Electric Company, in 1907, and 2 years later to New York as vice-president and general manager of the parent concern. In 1923 he was elected president of the company. He became chairman of the board and chairman of the executive committee in 1947. In 1950 Mr. Tidd resigned as chairman of the board but remained a director and consultant to the company. He was a member of the Edison Electric Institute, the National Electric Light Association, and the Association of Edison Illuminating Companies.

Benjamin W. Creim (AM '20, M '28, F '31), Administrator, Southeastern Power Administration, Elberton, Ga., died on February 4, 1952. He was born on September 19, 1898, in Chicago, Ill., and attended Los Angeles Polytechnic College and George Washington University in Washington, D. C. Mr. Creim saw active service in both World Wars and was a Commander in the United States Navy at the end of the war in 1945. Mr. Creim was one of the early pioneers in the public power field and his employment includes positions with the Los Angeles Bureau of Power and Light, the Modesto Irrigation District of California, the Rural Electrification Administration, the Bonneville Power Administration, the Bureau of Reclamation and the Southeastern Power Administration. In 1950, he was appointed Administrator of the newly created Southeastern Power Administration to exercise the responsibilities of the Secretary of the Interior in the marketing of federal hydroelectric power throughout the ten states of the Southeast.

Jaroslav George Hlavac (AM '24, M '31), transmission engineer, Central Hudson Gas and Electric Corporation, Poughkeepsie, N. Y., died on May 17, 1952. Mr. Hlavac was born on April 21, 1896, at Jicin, Czechoslovakia, and was graduated as an electrical engineer from the State Institute of Technology, Prague, in 1921. He came to America in 1922 and started his association with Central Hudson Gas and Electric Corporation in 1925. During World War II, he served as a colonel in the United States Army in the Pacific theater. With Central Hudson, Mr. Hlavac specialized in transmission-line design and in 1948 was the engineer-in-charge of the design and installation of a submarine cable under the Hudson River.

Joseph Wilson Mullally (AM '45), manager of utility sales, Anaconda Wire and Cable Company, New York, N. Y., died on June 10, 1952. He was born on December 5, 1897, in St. Louis, Mo., and attended the University of Notre Dame. He enlisted in the United States Navy in 1917, served in the Orient, was White House aide to President Calvin Coolidge, and remained in the service until 1930, when he resigned with the rank of lieutenant, senior grade. Mr. Mullally joined the Anaconda Wire and Cable Company in 1930. From November of that year to July 1938 he was district manager in Pittsburgh, Pa. During World War II, between 1942 and 1945, he was chief of the Wire Mill branch of the Copper Division of the War Production Board. In March 1951, he became a consultant in the Copper Division of the National Production Authority. In May of the same year he was made Deputy Director of the Division. He returned to the Anaconda Wire and Cable Company in December 1951 as manager of utility sales.

Arthur Leslie Harding (AM '13, M '28, F '31, Member for Life), retired, Ebasco Services, Inc., New York, N. Y., died on May 2, 1952. Born on July 15, 1888, in Boston Mass., he was graduated from Massachusetts Institute of Technology in 1910. He was associated with Ebasco from 1916 until his retirement in 1946. Mr. Harding was a member of the National Electric Light Association, Edison Electric Institute, and the Association of Illuminating Companies. He had served on the following AIEE committees: Electric Machinery (1929–34); Standards (1934–35); and the Board of Examiners (1942–45).

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of June 19, 1952, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Bangs, G. L., electrical engr., Rochester Gas & Electric Corp., Rochester, N. Y.
Berkovitz, H., project engr., Westinghouse Electric Corp., Jersey City, N. J.
Blanning, R. B., application engr., General Electric Co., Schenectady, N. Y.
Campbell, D. A., Jr., lines & substation supt., Pennsylvania Power & Light Co., Hazleton, Pa.
Chow, W. T., senior engr., Arma Corp., Brooklyn, N. Y.
Christian, C. A., design engr., Westinghouse Electric Corp., East Pittsburgh, Pa.
Dunn, C. V., owner, American Neon Supply Co. Kansas City, Mo.
Gadler, S. J., asst. chief, aircraft radiation lab., Wright-Patterson AFB, Dayton, Ohio
Gehlsen, R. G., mgr., elec. conn. div., Joy Mfg. Co., St. Louis, Mo.
Gittings, W. N., commercial engr., General Electric Co., Philadelphia, Pa.
Groeteke, E. A., rectifier engr., Vickers Electric Div. St. Louis, Mo.
Hansen, W., dist. control specialist, General Electric Co., Boston, Mass.
Harris, E. H., asst. to div. engr., General Electric Co., Lynn, Mass.
Hemker, H. F., mgr., General Electric Co., Memphis, Tenn.
Higgins, A. T., asst. engr., Pacific Gas & Electric Co. San Francisco, Calif.
Higgins, C. E., electrical engr., Dayton Rubber Co., Dayton, Ohio
Homan, R. A., standards engr., The Emerson Electric Mfg. Co., St. Louis, Mo.
Hopkins, R. O., substation engr., Gulf States Utilities Co., Beaumont, Tex.
Hubley, F. N., electrical supervisor, Westinghouse Electric Corp., Boston, Mass.
Johnson, W. C., toll & transmission engr., Ohio Bell Telephone Co., Columbus, Ohio
Johnston, D. L., design engr., General Electric Co., Pittsfield, Mass.
Kirkpatrick, A. E., electrical design engr., Commonwealth Associates, Inc., Jackson, Mich.
Klumb, R. E., transportation engr., General Electric Co., St. Louis, Mo.
Lee, J. R., electrical engr., Pittsburgh Lectromelt Furnace Corp., Pittsburgh, Pa.
Lewis, L. F., industrial application engr., General Electric Co., Schenectady, N. Y.
Long, F. V., project engr., microwave comm., Texas Eastern Transmission Corp., Shreveport, La.
Martin, P. N., project engr., Struthers-Dunn, Inc., Philadelphia, Pa.
McCurry, E. T., electrical engr., General Electric Co., Philadelphia, Pa.
McNutt, C. A., chief, power planning sec., U. S. Corps of Engineers, Nashville Dist., Tenn.
Miller, G. M., application engr., General Electric Co., Schenectady, N. Y.
Murphy, J. R., dist. mgr., General Electric Co., Seattle, Wash.
Nelson, J. L., asst. engr., West Penn Power Co., Pittsburgh, Pa.
Nelson, W. E., inductive co-ord. engr., Public Service Co. of Northern Illinois, Chicago, Ill.
Noel, E. B., dev. engr., General Electric Co., Cleveland, Ohio
Oehlwein, O. L., power supervisor, Public Service Co. of Northern Illinois, Chicago, Ill.
Olmsted, E. G., electrical engr., Dept. of Water & Power, City of Los Angeles, Calif.
Pynn, T. E., major, U. S. Army; 284—7th Ave., Brooklyn, N. Y.
Radin, C. J., electrical engr., John Graham & Co., Seattle, Wash.
Reed, R. A., dev. engr., Federal Telecommunications Lab., Nutley, N. J.
Riggs, M. L., engr., General Electric Co., Pittsfield, Mass.
Robertson, G. D., naval ord. dept., General Electric Co., Pittsfield, Mass.
Rohr, E. K., design engr., General Electric Co., West Lynn, Mass.
Smoot, A. W., assoc. electrical engr., Underwriters Laboratories, Inc., New York, N. Y.
Snell, T. A., electrical field engr., Public Service Co. o Northern Illinois, Maywood, Ill.
Spielman, S. C., director of engg., Philco Corp., Philadelphia, Pa.
Stacy, J. E., project engr., Laboratory for Electronics, Inc., Boston, Mass.
Straub, H., electrical engr., U. S. Corps of Engineers, Alaska Dist., Seattle, Wash.
Weary, J. F., design engr., General Electric Co., West Lynn, Mass.
Westen, W. H., testing engrs., Commonwealth Edison Co., Chicago, Ill.
White, J. H. F., district inspector-in-charge, Consolidated Edison Co., Pleasantville, N. Y.
Wightman, F. N., application engr., Westinghouse Electric Corp., St. Louis, Mo.
Williams, J. B., section engr., Philco Corp., Philadelphia, Pa.

52 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before August 25, 1952, or October 25, 1952, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Bose, B., Damodar Valley Corp., Dist Hazaribagh, Bihar, India
MacLean, J. A., Metropolitan-Vickers Elec. Export Co. Ltd., Hamilton, Ont., Canada

2 to grade of Member

AMENDMENTS TO AIEE CONSTITUTION

At the Annual Meeting of the Institute on June 23, 1952, at the Summer General Meeting in Minneapolis, Minn., it was announced that the membership had voted to adopt the amendments to the Constitution which the Board of Directors had recommended on January 24, 1952. These constitutional amendments become effective on August 22, 1952, 60 days after the Annual Meeting when their adoption was announced.

ARTICLE II

MEMBERSHIP

Proposed Amendment No. 1:

The first paragraph of Section 4 now reads:

> 4. A Fellow shall at the time of transfer be at least 40 years of age and shall be a Member actively engaged in the electrical field (temporary unemployment excepted). He shall have had at least 15 years of active experience and shall have been in good standing in Member grade for at least 10 consecutive years immediately prior to the date of proposal for transfer to Fellow and shall qualify under paragraph "a" or "b" of this section. A person who at the time of admission to the grade of Member held membership in good standing in the principal national electrical engineering society of some other country of a grade for which the qualifications indicate a standing equivalent to that required for the grade of Member herein, may have such years of prior membership in that equivalent grade to a maximum of nine considered as a part of the requisite ten years in Member grade.

Delete the partial sentence beginning with "held membership . . . . ," in line 9, and ending ". . . for which," in line 11, and substitute the following:

"held in good standing in a cognate electrical engineering society of national scope in any country a grade of membership for which"

Proposed Amendment No. 2:

Paragraph "a," Section 5, now reads:

> a. An electrical engineer by profession. As such he shall be qualified to design, construct, manufacture, or operate important electrical work and shall have had responsible charge of the design, construction, manufacture, or operation of important electrical work for at least two years.

Delete the partial sentence beginning with "to design, . . . ," line 2, and ending with ". . . at least two years," line 5, and substitute the following:

"in and have had responsible charge for at least two years of important electrical design, construction, manufacture or operation."

Proposed Amendment No. 3:

Paragraph "d," Section 5, now reads:

> d. A person who holds in good standing in a principal national engineering society of some other country membership of a grade for which the qualifications indicate a standing equivalent to that required for Member grade under paragraphs "a" or "b."

Delete the partial sentence beginning with "holds in . . . , line 1, and ending with . . . which," line 3, and substitute the following:

"holds in good standing in a cognate engineering society of national scope in any country a grade of membership for which"

Proposed Amendment No. 4:

Paragraph "a," Section 6, now reads:

> a. An electrical engineer by profession. As such he shall be qualified under instruction and supervision to design, construct, manufacture, or operate electrical products or installations.

Delete the partial sentence beginning with "design . . . ," line 2, and ending with . . . "or installations," line 3, and substitute the following:

"undertake electrical design, construction, manufacture or operation."

ARTICLE III

ADMISSION, TRANSFER, AND EXPULSION OF MEMBERS

Proposed Amendment No. 5:

Section 11 now reads:

> 11. Fellow grade of membership shall be conferred by action of the Board of Directors on those members of ten years' good standing in Member grade whose outstanding work in electrical science or electrical engineering in any field is brought to the attention of the Board by five or more Fellows or Members who shall submit data that in the opinion of the Board is sufficient to substantiate the importance of the accomplishment and warrant the issuance of the citation and conferring of the honor. Transfer to Fellow may not be obtained by application.

Add the following sentence between the first and second sentences above:

"Sponsors shall, when proposing a candidate for Fellow grade, give reference to five (5) Fellows."

ARTICLE XI

AMENDMENTS

Proposed Amendment No. 6:

Section 68 now reads:

> 68. Amendments to this Constitution may be proposed by means of a petition signed by not less than one hundred (100) Fellows, Members, or Associate Members and received by the Secretary not later than February first; or by means of a Resolution adopted by the Board of Directors not later than February first. Such proposed amendment or amendments shall be submitted to legal counsel by the Board of Directors, and if, in the opinion of such counsel, they are in accordance with the laws under which the Institute is organized, a copy shall be mailed, with a letter ballot, to each Fellow, to each Member, and to each Associate Member, not later than March 1.

Delete the words "February first" in line 4, and substitute the words "the fifteenth day of February."

Make the same substitution in line 6.

Delete the words "March 1" in line 12, and substitute the words "the first day of April."

Proposed Amendment No. 7:

Section 69 now reads:

> 69. Votes, to be considered, shall be written or printed and received, through the mail or otherwise, by the Secretary not later than the first day of May. The Secretary shall hand these votes unopened to the Committee of Tellers, which shall count such votes and make a sealed report to the Board of Directors in duplicate, of which one copy shall forthwith be filed with the Secretary, and of which the other copy shall remain in possession of the chairman of the committee, who shall hand this report to the presiding officer of the Annual Meeting. In the absence of this report by the chairman of the committee the Secretary shall produce the duplicate copy and hand the same to the presiding officer of the meeting. The presiding officer shall then cause the report to be read. If the total vote be not less than twenty per cent (20%) of the total corporate membership of the Institute and if seventy-five per cent (75%) or more of all the Fellows, Members, and Associate Members voting shall declare themselves in favor of the proposed amendment or amendments, the same shall become a part of the Constitution.

Delete the word "May" in line 3, and substitute "June."

Proposed Amendment No. 8:

Section 70 now reads:

> 70. Amendments shall take effect thirty (30) days after their adoption, but officers and officers-elect of the Institute at the time any amendment becomes effective shall continue in office until the end of the terms for which they were elected.

Delete "thirty (30)" in line 1, and substitute "sixty (60)."

OF CURRENT INTEREST

Magnetronic Reservisor Automatically Handles Airplane Space Availability

An electronic "brain," the first of its kind in commercial use, has been put into service by American Airlines in New York, N. Y. The Magnetronic Reservisor is designed to keep accurate and up-to-the-moment information on seats available and to reduce to a matter of seconds the time it takes to make a passenger's reservation.

Developed jointly by American Airlines and The Teleregister Corporation at a cost of about $500,000, the machine represents 8 years of effort during which the tremendous growth of air travel brought the reservations problem to a crisis. It is the first application of the electronic digital computer principle to a commercial inventory problem.

By simple manipulation of keys on an agent set resembling a small adding machine, a ticket or reservations agent can determine, in a matter of seconds, space available and make or cancel reservations.

The Magnetronic Reservisor puts the entire inventory at the fingertips of both the reservations agents and the ticket agents. Ticket agents no longer need to call the Reservations Office to determine space or to make or cancel reservations. It is all done by push-button electronics.

The brain, housed in a specially air-conditioned room in American's hangar at LaGuardia Airport, consists of a battery of electronic tubes which do the necessary computing, and a "memory" in which is stored the inventory of seats. The memory consists of two magnetized drums which rotate at 1,200 rpm.

A running inventory of space on more than 1,000 American Airlines flights for a period of 10 days is recorded on the surface of the drums in the form of tiny areas of magnetized material.

The agent sets have access to the brain through direct cable from the Reservations Office in a nearby room and through leased lines from the remote ticket offices throughout the metropolitan area.

As an example of how the Reservisor works, assume that a passenger has requested three reservations for a flight from New York to Chicago: 1. The agent selects a destination plate from a file at his elbow. This plate is notched, much as a house key. 2. He inserts the plate in a slot behind eight lucite push-button lamps on the agent set. This sets up the connection with specific areas of the memory drum containing data on the proper flights. The sections of the plate above the eight lucite keys have printed data on flight number, departure time, and so forth, for each of eight flights. 3. The agent then pushes buttons designating the date and number of seats requested, and activates the "availability" key. 4. In as little as 3/4 of a second the Reservisor responds by lighting the lucite lamps corresponding to those flights which have at least three seats available. 5. The passenger makes his choice of flight, the agent depresses the lighted lucite key for that flight and flips a key to "sell." 6. In as little as 1/4 of a second, a green light on the agent set indicates that the machine has completed the transaction, subtracting three seats from the inventory for that flight on the drum.

If the passenger wants his three seats on one specific flight, the agent can skip the availability check. In that case, he inserts the destination plate, sets the date and number of seats, and flips the "sell" key. If seats are available, the green light indicates that the reservation has been made. If the flight has been sold out, however, the machine rejects the reservations with an amber light.

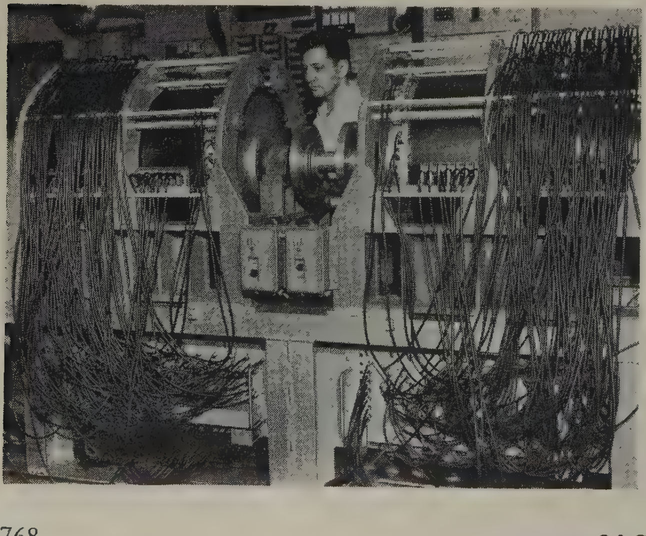
When a flight is sold out, it is desirable that supervisory personnel, as well as remote stations in other cities not directly connected to the Reservisor, be apprised of this fact as soon as possible. A telegraph printer-perforator at the central office calls attention to each sell-out by printing the date and flight information on any flight as it reaches the sold-out condition. This function is initiated by the computer when a seat inventory reaches zero. It is just as desirable many times to know how near a flight is to being sold out. A master agent set used by supervisory personnel brings back the exact number of seats remaining in the inventory.

Cancellation operations are similar to sell operations except, of course, that the number of seats canceled is added to the stored inventory by the computer.

A special condition exists when a flight is sold out. In this event, there is a possibility that there may be a wait list which should receive priority if any cancellations are received. For this reason, the Reservisor computer rejects cancellations into sold-out flights from all except a few agent set positions where a wait list file is maintained.

A view of the agent's set, with a drawer file of destination plates, in use by a reservations agent. The destination plate gives the number, departure time, origin, and destination of flights and is used to select a specific group of flights

In addition to the 10-day period available for complete inventory selection, the Reservisor provides two additional storage sections which may be used to indicate space availability on a "yes-no" basis.



The "Memory" maintains the 10-day flight inventory as magnetized spots on the surface of the Reservisor's rotating storage drums, which turn at 1,200 rpm. Requests are routed from the computer which adds to or subtracts from the inventory and then sends the answer back to the agent's set

To insure a high degree of accuracy in 24-hour-a-day service, the Reservisor is equipped with two complete Magnetronic systems, functioning simultaneously in synchronism. Automatic checking equipment continuously compares the performance of one system against another. If at any point in the handling of an agent-set call both systems are not similarly conditioned, the call is stopped, the error lamp on the agent set lights, and an alarm is sounded. At the same time a page printer records the attempted operation and the progress made up to the time of disagreement.

The agent may attempt his call again and, if the trouble was a minor temporary one, will get his proper answer. Meanwhile, a maintenance man, referring to the tell-tale monitor printer, will track down the offending unit and replace it, all sensitive elements being jack-mounted to expedite this. If necessary, he can cause a red light to appear on the agent sets in all outlying offices to indicate "temporarily out of service." If a serious trouble is found in one system, or if it is desired to shut it down for a general inspection, it can be removed from service, leaving the second system functioning normally. Upon restoration to service, the memory of the one system is made to conform with the other.

Although designed for the airline's specific problem, the Magnetronic Reservisor can be applied to any business in which rapid access to a large inventory needs to be made quickly, accurately, and reliably.

Future Meetings of Other Societies

American Chemical Society. Seventh National Chemical Exposition. September 9–13, 1952, Chicago Coliseum, Chicago, Ill.

American Standards Association. Third National Standardization Conference. September 8–10, 1952, Museum of Science and Industry, Chicago, Ill.

Illuminating Engineering Society. National Technical Conference. September 8–13, 1952, Edgewater Beach Hotel, Chicago, Ill.

Instrument Society of America. National Instrument Conference and Exhibit. September 8–12, 1952, Cleveland, Ohio.

Photographic Society of America. Technical Division. August 12–16, 1952, Hotel New Yorker, New York, N. Y.

The American Society of Mechanical Engineers. Fall Meeting. September 8–11, 1952, Sheraton Hotel, Chicago, Ill.

Most Powerful "Human Centrifuge" Goes into Operation at Naval Laboratory

The world's largest and most powerful "human centrifuge," a machine to subject pilots to extreme gravitational conditions encountered in sonic-speed aircraft, has been put into operation at the United States Naval Aviation Medical Acceleration Laboratory, Johnsville, Pa.

Built by the McKiernan-Terry Corporation of Harrison, N. J., the centrifuge is capable of accelerating from a dead stop to 173 miles per hour in less than 7 seconds. It will speed up from zero to approximately 90 miles per hour in $1^{1}/_{2}$ seconds.

The giant "whirligig" is capable of exerting a force equal to 40 times the gravitational pull of the earth on a pilot seated in a gondola at the end of a 50-foot rotating arm. It will be used by the Navy to evaluate human tolerance to acceleration and to study the physiological systems which limit the tolerance.

To obtain these operation requirements, the centrifuge is powered by one of the largest vertical d-c motors ever built. The huge 180-ton drive has a rating of 4,000 horsepower and can develop 16,000 horsepower momentarily at 48 rpm.

Special electronic controls are operated from a blister suspended from the ceiling of the centrifuge room. From this blister, varying speeds of the arm and the position of the gondola can be controlled by one man.

The spheroidal aluminum gondola is suspended in double gimbals which can be rotated by means of motors mounted on the arm. Thus, a man seated in the car can be somersaulted or tipped into any position while he is swept around the large circle described by the arm.

Since the human "guinea-pig" is visible to researchers only when the centrifuge is motionless, high-speed television, X-ray, and motion picture cameras are mounted in the gondola. This recording equipment is linked to control and observation stations by means of slip rings on the machine's rotor shaft.

According to engineers who worked on the project, the centrifuge varies greatly from those previously constructed. The older machines require a much longer time to wind up and develop a fair degree of gravity stress. Since today's jet airplanes develop extreme gravitational stresses in violent maneuvers, the Johnsville installation was designed specifically to build up the largest stress possible in a minimum period of time.

Besides the huge centrifuge motor, the gimbal drives, and controls, the General Electric Company supplied switchgear, unit substation equipment, amplidyne exciters, and a motor-generator set for the installation. The motor-generator set consists of a 4,200-horsepower motor and two 1,500-kw generators.

The human centrifuge chamber of the Aviation Medical Acceleration Laboratory. The centrifuge arm, gondola, gimbals, counterweight, and gimbal control weigh a total of 84,000 pounds. Shown at far left is the gondola. At the upper right is the control blister

New Radar Set Maps Terrain Up to 200 Miles

A new lightweight radar set that "maps" every detail of terrain and weather obstacles up to 200 miles in front of an aircraft is now in production for the United States Air Force and Navy.

This advance radar unit, already installed on various military air transports, is also suited for commercial aircraft. At the present time, however, the equipment is being produced under Navy contract for military use only, and is scheduled for production under an Air Force contract.

The new unit permits the pilot to see a close-up of a selected area as if he were using a powerful telescope that could penetrate through darkness and clouds, and can be used for these four general types of operation: As a means of collision warning; it will show mountains or other aircraft in the vicinity. As an accurate indicator of weather conditions; it will show the position of thunderheads and other cloud formations, and will enable the pilot to avoid turbulent weather or select the safest course through it. As a means of position location when standard landmarks are not visible; it can pick up the signal of ground-based radar range units. As a means of mapping terrain; through a special discrimination circuit, it shows the pilot the salient characteristics of the land over which he is flying.

The range of the system can be selected by the pilot for distances up to 200 miles from the airplane. A selector switch permits the pilot to bring into view all obstacles and terrain within 5, 10, 30, 100, and 200 nautical miles of his airplane. On a recent flight from Westover Air Force Base, Mass., to Frankfurt, Germany, in a military *C-97* equipped with the new radar, the first islands of the Azores were observed at a distance of 195 miles from an altitude of 17,000 feet.

The device, designed solely for navigation and obstacle and weather detection, weighs a total of 173 pounds before installation, and is pressurized to operate at altitudes up to 50,000 feet. It is the first system of its kind to go into production that has both military and commercial application.

At the pilot's selection, the signal from the radar antenna can be transmitted either in the form of a pencil beam for obstacle detection and general search, or in the form of a vertical fan for mapping and navigational aid. The pencil beam is somewhat like a flashlight with invisible rays which will show the pilot either everything ahead of his airplane up to a distance of 200 miles or everything within a full circle with a 400-mile diameter. The beam can be raised or lowered to enable the pilot to measure the height of thunderheads and other clouds, or to look at the ground ahead and below his airplane.

The vertical fan position is used for navigation and shows a picture of the ground up to a distance of 200 miles ahead of and to either side of the aircraft.

The equipment is also designed to supplement landing approach equipment by picking out airfields and, under certain conditions, runways. In addition, it provides the pilot with a visible check of the other landing and approach instruments in the airplane, and with any directions that he may receive by radio from ground approach officers.

The antenna is mounted on a special platform which can be controlled by a gyroscope to remain stationary, so that the signal is not distorted by the airplane's pitch and roll. This means that while the aircraft maneuvers, the pilot still receives a true picture of the ground and air ahead, even though his airplane may be momentarily off course.

S. S. United States Equipped With Latest Navigational Aids

The *S. S. United States* has been provided with the most modern version of every proved navigational aid intended to facilitate the navigation and handling of the ship and to promote the safety of the ship, its passengers, and its crew. As an additional safety measure practically all the equipment necessary to navigate the ship and transmit orders dealing with its operation is installed in duplicate.

One of the most unusual features of the *United States* is its all-aluminum radar mast, on which are located the two antennas for the ship's electronic eyes. These radar units, which may be operated singly or simultaneously, on long or short range, will enable the ship to sail safely through fog and darkness. The ship is equipped with an echo-depth sounder for calculating the depth of the water. A gyro-pilot enables the ship to be steered automatically with no help from the helmsman should it be necessary to do so.

As well as being equipped with regular electric telephones, the *United States* is provided with many others that are sound-powered. These sound-powered telephones require no batteries or other outside power sources and are actually operated directly by the voice speaking into the mouthpiece. They operate with efficiency even in the high noise level of an engine room and insure uninterrupted communication during any emergency. A telephone is installed in each stateroom in all three classes.

The opened or closed position of each of the ship's many watertight doors and firescreen doors is indicated on a panel located in the damage control station, and the damage control officer may, if the need arises, close individual or all watertight or firescreen doors from this location.

Ship's service power aboard the *S. S. United States* is alternating current. Experience obtained in the design of large naval vessels and some commercial tankers demonstrated that the over-all weight of an a-c plant would be considerably less than a d-c plant, and that many thousands of pounds would be saved in the weight of cable for the electric power distribution systems because of the reduction in size of copper conductors and in the reduced weight of motors, generators, and other equipment, with consequent economies in the use of critical material. Another important advantage in the use of alternating current is the lesser maintenance required on a-c squirrel-cage induction motors.

There are some motor-driven auxiliaries installed on the *United States* which do not lend themselves to a-c power because of the inherent lack of simple wide-range speed control for a-c motors. Therefore, certain auxiliaries requiring a fine degree of speed control are direct current, but these represent a very small percentage of the total motor installation.

In order to provide some illumination throughout the vessel, and to operate certain damage-control power equipment in the event of failure of all or part of the ship's service electric generating plant or distribution system, a completely separate emergency power supply and distribution system has been installed. Under normal operation, electric power for the emergency system is obtained from the ship's service generators through the emergency generator switchboard, but in the event of shutdown of the ship's service generators the source of power is automatically transferred to the emergency generating plant. The emergency diesel-engine-driven generators will start automatically upon the failure of ship's service power.

The S. S. United States, after breaking transatlantic speed records, arrives at her home port of New York, N. Y. The ship is a triumph in marine engineering and planning. Largest and fastest passenger vessel ever built in this country, the S. S. United States is the first luxury liner conforming to the standards of the United States Navy. She can be converted, if necessary, to carry about 14,000 troops.

ASEE Annual Meeting Held at Dartmouth College, June 23–27

The 60th Annual Meeting of the American Society for Engineering Education (ASEE) was held at Dartmouth College, Hanover, N. H., from June 23 to 27, 1952.

Willis R. Woolrich, dean of the University of Texas, was elected president for the coming year. Dr. Eric A. Walker, dean of the School of Engineering, Pennsylvania State College, was named chairman of the Engineering College Research Council and a vice-president of the society. Dr. Kurt F. Wendt, associate director of the Engineering Experiment Station at the University of Wisconsin, was named vice-chairman of the Council. Others elected to the Research Council's board of directors were: Dr. F. C. Lindvall, chairman of the division of engineering, California Institute of Technology; Dr. Raymond J. Woodrow, co-ordinator of research at Princeton University; Dr. J. Hugh Hamilton, director of the Engineering Experiment Station, University of Utah; and Dr. T. L. Joseph, assistant dean of the School of Mines and Metallurgy at the University of Minnesota.

Underlying all the talks and discussions of engineering and education given was the basic recognition that an understanding of the way people feel and act and dream was even more important than an understanding of the inner workings of the atom. Dr. C. C. Furnas, Director of Cornell Aeronautical Laboratory, gave knowledge last place in a list of qualities of successful engineers. Ahead of knowledge Dr. Furnas placed drive, imagination, judgment, and facility in human relations. Even in the establishment of technical criteria, the human element was stressed by Professor George R. Town of Iowa State University. In the same vein Lillian Gilbreth, president of Gilbreth, Inc., told engineers that they should devote their efforts to making the factory, the mine, the office, the store, the school, and the home places where people do more at less cost in motion, in energy, in time.

University of Texas Dean Willis R. Woolrich, newly elected president of the American Society for Engineering Education, being congratulated by the society's retiring president, Dean S. C. Hollister of Cornell University (right)

Other addresses were given by Dean S. C. Hollister of Cornell University who again voiced concern over the shortage of engineers; Professor Carl Muhlenbruch of Northwestern University; John D. Leith, associate dean of Lehigh University; Pemberton Johnson of Educational Testing Service; William C. Krathwohl of Illinois Institute of Technology; and John Sloan Dickey, president of Dartmouth College.

EJC Urges Civilian Control of Reservist Recall

The Engineering Manpower Commission of Engineers Joint Council (EJC) urged civilian control of the recall of reservists to active duty in a statement before a Subcommittee of the Committee on Armed Services, United States Senate, during hearings recently in connection with the Armed Forces Reserve Act of 1951.

In presenting the statement by C. H. Brown, Chairman of the Engineering Manpower Commission, Dr. N. A. Shepard, Chemical Director, American Cyanamid Company, and member of the Engineering Manpower Commission of EJC, stated, "There is a patriotic obligation upon every man and woman for appropriate service of which each is capable in maintaining the security of the United States. We are faced with a critical shortage of engineers and scientists." There is a current backlog of demand for more than 60,000 engineers. In addition it has been estimated reliably that 30,000 new engineers are needed each year. For the next 5 years the colleges will be graduating an average of 19,000. It is therefore fundamental that each person be utilized at his highest capacity.

"Maintaining a sound economy and the required development and production of weapons are both essential if the man at the front is to be effective. These are part of

Organizations Meeting at Centennial of Engineering, Chicago, 1952

Organization	*Headquarters*	*Sept. '52*
Am. Assn. of Engrs.	Lake Shore Club	3
Am. Assn. for Adv. of Science	Ill. Inst. of Tech.	4
Am. Chem. Soc. (Chicago Sec.)	Coliseum	9–13 incl.
Am. Concrete Inst.	Conrad Hilton	11, 12
Am. Geophysical Union	Del Prado & Conrad Hilton	11, 12
Am. Inst. of Architects	Museum of Sci. & Ind.	8
Am. Inst. of Chem. Engrs.	Palmer House	10–13 incl.
Am. Inst. of Consulting Engrs.	University Club	8
Am. Inst. of Elec. Engrs.	Congress	10, 11, 12
Am. Inst. of Mining & Met. Engrs.	Palmer House	3–7 incl.
Am. Iron & Steel Inst.	Palmer House	11
Am. Meterological Soc.	Del Prado & Conrad Hilton	11, 12
Am. Power Conf. (Spons. by Mid-West Power Conf.)	University Club	4
Am. Public Health Assn. (Eng. Sect.)		
Am. Railway Engr. Assn.	Palmer House	8, 9, 10
Am. Rocket Society	Sheraton	
Am. Soc. for Eng. Educ.	W. Soc. Engrs. Hdqs., Sheraton	3, 4, 5
Am. Soc. for Agr. Engrs.	La Salle	8, 9
Am. Soc. of Civil Engrs.	Conrad Hilton	3–13 incl.
Am. Soc. of Lubrication Engrs.	Sherman	8, 9, 10
Am. Soc. of Mech. Engrs.	Sheraton	8–11 incl.
Am. Soc. of Safety Engrs.	La Salle	5
Am. Soc. for Test. Mat.	Sherman	10, 11
Am. Soc. of Tool Engrs.		9
Am. Standards Assn.	Museum of Sci. & Ind.	8, 9, 10
Am. Welding Soc.	Jointly with other societies	
Armour Research Found.		
Assn. of Consulting Engrs.	Sheraton	5
Boston Soc. of Civil Engrs.		9
Chi Epsilon Fraternity	Ill. Inst. of Tech.	12, 13
Chicago Tech. Council	W. Soc. Engrs. Hdqs.	11
Council of Eng. Soc. Secretaries	Sheraton	11, 12
Engrs. Council for Prof. Development	Sheraton	5, 6
Eng. Inst. of Canada	Conrad Hilton	5
Ill. Eng. Council		6
Ill. Soc. of Prof. Engrs.	Sherman	5
Illuminating Eng. Soc.	Edgewater Beach Hotel	8–11 incl.
Industrial Man. Soc.		11
Inst. of Radio Engrs.		12
Inst. of Traffic Engrs.	Sherman	8–11 incl.
Int. Commission on Irrig. & Drainage	Conrad Hilton	8
Int. Commission on Large Dams	Conrad Hilton	5
M.I.T. Club of Chicago		9
Natl. Conf. on Ind. Hydraulics	Sherman	4, 5
Natl. Council of State Bds. of Eng. Exam.	Conrad Hilton	9–12 incl.
Natl. Soc. of Prof. Engrs.	Sherman	5, 6
Soc. for Adv. of Mgment.	Ill. Inst. of Tech.	11, 12
Soc. of Amer. Military Engrs.	Conrad Hilton	13
Soc. of Automotive Engrs.	Knickerbocker	4
Soc. of Naval Arch. & Marine Engrs.	Sherman	5, 6
Soc. of Women Engrs.	W. Soc. Engrs. Hdqs.	5, 6
Western Soc. of Engrs.	W. Soc. Engrs. Hdqs.	4
World Power Conf.	Drake	4

an inseparable whole in maintaining the security of our Nation," Dr. Shepard declared. He pointed out also that "The proper allocation of critical skills to the Armed Forces and the necessary civilian economy will thus require a very careful process of selection. In addition to selecting those to be recalled for military service, the agency governing recalls must also select those for service in the essential civilian economy including defense development and production."

In stressing the control of a civilian agency, Dr. Shepard asserted, "Since this selection will be for service in the essential economy as well as for military service, reservists other than those in active organized units of the Ready Reserve should be called to active duty by a civilian agency such as Selective Service."

In maintaining the needed flow of young engineers, Dr. Shepard stated that the recall to active duty of the required number of professional and scientific students should be held in abeyance until completion of their professional study or until they cease to satisfactorily pursue such study.

New Electronic Viscometer Found Useful in Blood Studies

A new electronic viscometer, which simplifies many difficult measurements of the viscosity of liquids, has been developed at the David Sarnoff Research Center, Radio Corporation of America (RCA), Princeton, N. J.

Called a vibrating-plate viscometer, the RCA device has been used in studies of human blood clotting rates and it has been found that instruments such as this can open new fields of medical and biological study.

Besides its use in blood clotting studies, the device has been used experimentally by technicians of the United Clay Mines Corporation, Trenton, N. J., in charting the rates at which clay preparations harden in their molds, a new and valuable type of measurement in the ceramics industry.

The new RCA viscometer, a developmental model, can record at any range from low-viscosity alcohol to high-viscosity cold molasses. Its measurements are virtually instantaneous and they can be recorded over an indefinite period of time on a moving paper chart. The instrument can take measurements of a liquid whether it is in a huge vat or in a tiny container holding a quarter of a thimble full.

The vibrating-plate viscometer consists of a thin metal disk, 0.2 inch in diameter, at the end of a metal reed less than an inch long. An electromagnetic motor causes the disk to cut back and forth through the liquid at approximately 800 cycles per second.

The plate makes its widest swing when oscillating in air but when dipped in a liquid the swing is restricted by the viscosity. Mounted on each side of the reed are piezoelectric blocks, which generate a voltage when stress is applied to them through the bending of the reed. An alternating voltage thus is generated which is proportional to the swing, or amplitude, of the plate. The more viscous the fluid, the more restricted the plate's vibrations are. The resulting voltages are determined readily on a vacuum tube voltmeter and simply converted to viscosity values.

Microwave Television Network to Be Installed in Cuba

The Philco Corporation, Philadelphia, Pa., has been selected by Circuito CMQ, operators of the leading radio and television chain in Cuba, to equip and install the largest television microwave relay network outside the United States, it was announced recently.

Plans call for a 16-hop microwave system over a 500-mile route from Havana to Santiago, Cuba. Initial installations will be seven stations linking Havana with Santa Clara. Designed to provide three channels for complete television and radio program service, the system also includes three additional channels for general communications use along the network.

G-E Opens Switchgear Laboratory

A grandstand of about 500 utility and industrial officials at the General Electric Company's dedication of its new Switchgear Development Laboratory, Philadelphia, Pa., June 19, watch a television moderator explain one of the day's demonstrations. The new laboratory is the highest capacity switchgear development laboratory in the world. It will be used for developing, designing, and testing power equipment (See EE, Jul' 52 pp 608–14)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

IES LIGHTING HANDBOOK. The Standard Lighting Guide. Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y., second edition, 1952. Various paging, illustrations, tables, charts, graphs, diagrams, 9 by 6 inches, bound. $8. In simple terms and highly condensed style this reference book presents the accumulated knowledge of some 50 years of lighting progress, evaluated and interpreted by specialists. Both the theoretical aspects and practical applications are considered. Many illustrations and a detailed index aid in the use of the volume. Data on many types of commercially available equipment are included. Classified references to the original literature are grouped at the end of each section. Over 75 per cent of the material in this edition is new or revised.

INDUSTRIAL HEAT TRANSFER. By F. W Hutchinson. The Industrial Press, 148 Lafayette Street, New York 13, N. Y., 1952. 326 pages, tables, charts, 9¼ by 6¼ inches, bound. $6. A combined text and reference book, providing a selective approach to problems of heat transfer analysis and to the rapid evaluation of coefficients and rates. In addition to the basic relationships for conduction, radiation, convection, and combined heat transfer for which both equations and graphs are given, there are individual graphs for forced convection of some 70 gases and liquids, alphabetically arranged. The graphs are scaled for accuracy comparable to the equations, and explanatory text material appears on the facing pages.

INDUSTRIAL MAGNETIC TESTING. By N. F. Astbury. The Institute of Physics, 47, Belgrave Square, London, S. W. 1, England, 1952. 132 pages, tables, diagrams, charts, 9¾ by 6¼ inches, bound. 25s.0d. An analysis of methods for testing and measuring the properties of magnetic materials used in industry, this text will be useful to manufacturers and users of these materials. Among topics dealt with are the magnetic circuit, instruments, permeability and hysteresis measurements, power loss measurements, a-c bridge and potentiometer measurements, permanent magnet testing, and properties of materials.

INDUSTRIAL PROCESS CONTROL BY STATISTICAL METHODS. (Industrial Organization and Management Series.) By John D. Heide. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1952. 297 pages, tables, charts, 9¼ by 6¼ inches, bound. $6. Providing both an introduction to the statistical methods required and an explanation of the practical and technical problems involved in their application, this book is useful as a text for the student or as a manual for the plant manager. It covers process frequency distributions, control charts, and limit lines; discusses the study of process data, factory installation, and practical program aids; and deals in general with organization, administration, and the evaluation of test procedures and results.

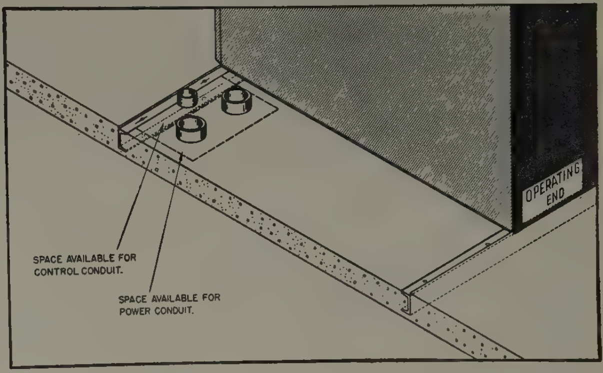
INTRODUCTION TO ELECTRONIC CIRCUITS. By R. Feinberg. Longmans, Green and Company, Inc., 55 Fifth Avenue, New York 3, N. Y. 1952. 163 pages, diagrams, charts, 8¾ by 5¾ inches, bound. $3.50. This book deals with external effects of electronic devices and their utilization in electric-circuit technique. These effects are rectification, control of current, amplification, frequency multiplication and intermodulation, negative-resistance performance, and electronic-switch action. In treating these effects it is assumed that the electron-transit time is negligible in the time scale of voltage and current changes and has no influence on performance.

VADE-MECUM. 1952. P. H. Brans, Ltd., 28 Prins Leopold At, Borgerhout, Antwerp, Belgium, 9th edition, 1952. 416 pages, tables, 11½ by 8 inches, paper. $5. This comprehensive annual guide provides a general index of world-wide radio tube types, tables of tube characteristics, and tables of base connections. This edition contains only receiving and transmitting tubes, which are tabulated in numerical and alphabetical order. Army tube types and specialized tubes will be listed in a new edition. The introduction and the necessary directions or instructions are given in eight languages.

PROVES ITS ENGINEER APPEAL

CONSTRUCTION ENGINEERS

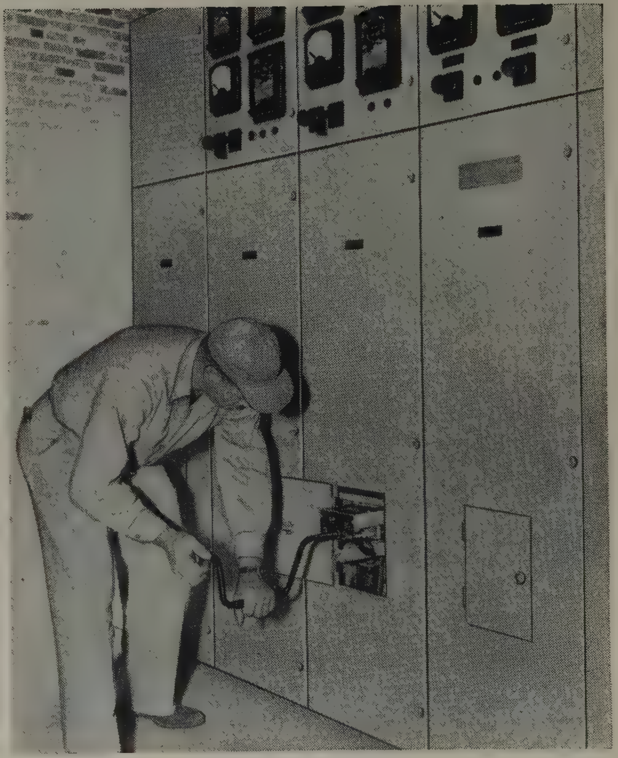
I-T-E provides switchboard floor plans, front view drawings and single line diagrams well ahead of shipment. When you're ready, I-T-E forwards channel bases—your equipment goes in right on schedule! Control and primary cables can enter structure at top or bottom. Control cable connections are located just inside the removable rear panel. You have them completely accessible for inspection and checking *without* de-energizing the circuit, *without* removing the breaker, *without* entering the switchgear structure.


OPERATING END
SPACE AVAILABLE FOR CONTROL CONDUIT.
SPACE AVAILABLE FOR POWER CONDUIT.

OPERATING ENGINEERS

Important operating advantages of I-T-E Metalclad Switchgear save steps and guard your safety. Here are just a few of them:

1. Secondary circuit testing without removal of breakers from the stationary structure. No separate operation of secondary disconnecting devices is required.
2. The double interlock assures complete safety of personnel and equipment—guards against improper insertion or withdrawal of the circuit breakers. Interlocks are built into the circuit breaker—eliminating complicated engagement mechanisms between the breaker and structure. Adjustments are simplified and interchangeability is assured.
3. Circuit breaker control-relay is mounted on breaker truck; (when breaker comes out, relay comes out. No "climbing" into structure to inspect control-relay).
4. Truck-mounted horizontal removable elements eliminate hours of maintenance usually required for complicated elevator mechanisms.



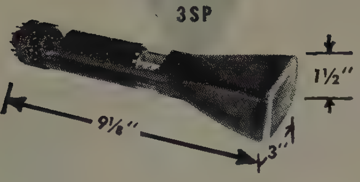
Full operating positioning is accomplished by mechanical racking.

Specify I-T-E METALCLAD SWITCHGEAR

I-T-E CIRCUIT BREAKER CO. • 19th & HAMILTON STS. • PHILA. 30, PA.

R&IE Equipment Division, Greensburg, Pa. • Canadian Mfg. & Sales: Eastern Power Devices, Ltd., Toronto • Export Sales: Philips Export Corp., N.Y. 17, N.Y.

THE
RAYONIC®
CATHODE RAY TUBES
BY WATERMAN



Since the introduction of Waterman RAYONIC 3MP1 Tube for miniaturized Oscilloscopes, Waterman has developed a rectangular Tube for multi-trace oscilloscopy. Identified as the Waterman RAYONIC 3SP, it is available in P1, P2, P7 and P11 screen phosphors. The face of the Tube is 1½"x3" and the over-all length is 9⅛". Its unique design permits two 3SP Tubes to occupy the same space as a single 3" round tube, a feature which is utilized in the S-15-A TWIN-TUBE POCKETSCOPE. On a standard 19" relay rack, it is possible to mount up to ten 3SP tubes with sufficient clearances for rack requirements. Thus 3SP RAYONIC tube is ideal for multi-trace oscilloscopic work.

Maximum 2nd anode voltage 2750 volts ... Satisfactory operation can be achieved at 600 volts ... Vertical deflection factor 52 to 70 volts DC per inch per kilovolt ... Horizontal deflection factor 73 to 99 volts DC per inch per kilovolt ... Grid cut-off voltage 2.8 to 6.7% of 2nd anode potential ... Focusing voltage 16.5 to 31% of 2nd anode voltage ... Heater 6.3V at .6 amp ... Twelve pin small shell duodecal base ... Tube can be mounted in any position . . . 3SP1 JAN approved.

WATERMAN PRODUCTS CO., INC.
PHILADELPHIA 25, PA.
CABLE ADDRESS: POKETSCOPE

WATERMAN PRODUCTS INCLUDE:
3JP1 & 3JP7 JAN RAYONIC CR TUBES
3JP2 & 3JP11 RAYONIC CR TUBES
3MP7 & 3MP11 RAYONIC CR TUBES
3RP1, 2, 7, 11 RAYONIC CR TUBES

Also POCKETSCOPES, PULSESCOPES, RAKSCOPES and other equipment

WATERMAN PRODUCTS

INDUSTRIAL NOTES ....

Eastman Kodak Executive Appointments. Neil S. Kocher, assistant general superintendent of film departments, Kodak Park Works, Eastman Kodak Company, Rochester, N. Y., has been appointed manager of film manufacturing. Dr. Louis K. Eilers, assistant to the manager of film manufacturing, has been named assistant manager of film manufacturing. Mr. Kocher joined the company in 1920 following his graduation from Syracuse University, and Dr. Eilers has been at Kodak Park since 1934.

Philco News. Richard W. Cotton has been given a temporary leave of absence from Philco Corporation to accept appointment as chairman of Electronics Production Board of the Defense Production Administration and Director of the Electronics Division of the National Production Authority, United States Department of Commerce. Mr. Cotton, assistant to the president on special assignments, will serve in his new post from June 16, 1952, to December 31, 1952, at which time he will return to Philco. James W. Skinner, Jr., vice-president—sales of the Refrigeration Division, has been appointed vice-president—distribution for all domestic divisions of the company.

Raytheon Expansion. An International Division has been established to handle the foreign business of the Raytheon Manufacturing Company. Ray C. Ellis, vice-president and manager of the Equipment Sales Divisions, will head the new organization. The Receiving Tube Division of the company also has opened a branch plant at 53 Spark Street, Brockton, Mass.

Westinghouse Appointments. Edward O. Boshell, chairman of the board and president of the Westinghouse Air Brake Company, has been elected a director of the Westinghouse Electric Corporation. Jay M. Allen has been named manager of manufacturing and Ricardo Muniz has been appointed superintendent of manufacturing at the company's Television-Radio Division plant in Sunbury, Pa. Other appointments include that of Myron Ceresa as manager of electroplating projects for the Special Products Development Division, R. N. Stoddard as midwest regional sales manager, and William A. Hayes as eastern regional sales manager for the Electronic Tube Division.

General Electric News. The new $6,000,000 Anniston (Ala.) Tube Works of the General Electric Company was officially opened on June 12. The plant will employ an estimated 2,000 people in the production of miniature glass receiving tubes for radio, television, and a variety of other communications and industrial equipment. At Louisville, Ky., where the multimillion-dollar Appliance Park is under construction, George T. Bogard was appointed manager of the utility sales department, Charles W. Theleen was named manager of special accounts, John F. McBride was made manager of sales planning, Herbert A. Warren will be manager of distribution, T. D. Eberhardt will continue as assistant manager of marketing and manager of marketing accounting, and Charles J. Enderle as assistant to the manager of marketing.

John Anderson, assistant secretary of the company, retired recently after almost 42 years of service. Mr. Anderson joined General Electric in 1910 and was closely connected with the company's apparatus sales organization.

George W. Henyan has returned to the company as assistant to the general manager of the Tube Department after serving as chief of the components branch of the National Production Authority's Electronics Division. Robert O. Bullard was named manager of Industrial and Transmitting Tubes for the department. Other recent appointments include those of David B. Lawton as manager of the transformer manufacturing plant at Rome, Ga.; Carl A. Salmonsen as acting general manager of the company's Control Department; Fred H. O'Kelley, Jr., as product manager for General Electric receiving tubes; and E. E. Bauer as manager of power transformer apparatus sales.

Sylvania Reorganization. In a reorganization of the Tube Distributor Sales Department, three new regional sales managers have been named by Sylvania Electric Products, Inc. G. C. Isham has been appointed eastern regional manager; J. H. Hauser was named midwestern regional manager; and W. G. Patterson was made Pacific regional manager.

Speer Carbon Company Consolidation. Speer Carbon Company, Saint Marys, Pa., and its subsidiaries, Jeffers Electronics, Inc., DuBois, Pa., International Graphite and Electrode Corporation, Niagara Falls, N. Y., and Speer Resistor Corporation, Saint Marys, have been consolidated into one company, the Speer Carbon Company, with headquarters at Saint Marys. The various subsidiaries will operate as divisions of Speer Carbon Company.

Otis Elevator Promotions. Otis Elevator Company has announced the following personnel changes. Arthur Lundeen is retiring as vice-president and general zone manager. Emmett W. Hines, formerly general service manager, succeeds Mr. Lundeen as general service manager and has been elected a vice-president. John F. Lawson, formerly assistant general service manager, has been named general service manager, succeeding Mr. Hines.

Plastics Society Officers. Gordon Brown was re-elected president of the Society of the Plastics Industry, Inc., for a second

(*Continued on page 28A*)

Radio-relay station at Evanston, Wyoming

a Watcher for lonesome places

Many of the Bell System's 107 radio stations connecting New York and San Francisco by microwave radio-relay stand on hills and mountains far from towns. Day after day, the apparatus does its duty; no man need be there to watch it. But when trouble threatens, an alarm system developed by Bell Telephone Laboratories alerts a testman in a town perhaps a hundred miles away.

A bell rings. The testman sends a signal which asks what is wrong. A pattern of lights gives the answer —a power interruption, an overheated tube, a blown fuse, a drop in pressure of the dry air which keeps moisture out of the waveguide. At intervals the testman puts the system through its paces to be sure it is on guard.

Sometimes the testman can correct a trouble condition through remote control, or the station may cure itself—for example, by switching in an emergency power supply. Sometimes the trouble can await the next visit of a maintenance man—sometimes he is dispatched at once.

This is one of the newest examples of the way Bell Laboratories adds value to your telephone system by reducing maintenance costs and increasing reliability.

Alarm-receiving bay in town. Lights on a chart report on 42 separate conditions affecting service. Telephone is to communicate with maintenance crews. Eleven alarm centers across the country cover all 107 radio-relay stations. Stations too far off the beaten trail for wire connections signal by very high frequency radio.

BELL TELEPHONE LABORATORIES

IMPROVING TELEPHONE SERVICE FOR AMERICA PROVIDES CAREERS FOR CREATIVE MEN IN SCIENTIFIC AND TECHNICAL FIELDS.

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INDOOR-OUTDOOR TYPE

3 KVA to 15KVA inclusive. Modern design for quick, neat installations. Light weight. Air cooled.

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25 KVA to 200 KVA inclusive. Extra large junction box speeds hook-up.

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(Continued from page 18A)

year at the annual meeting of the society. Mr. Brown, a vice-president of the Bakelite Company, Division of Union Carbide and Carbon Corporation, was a founder of the Society of the Plastics Industry, Inc., 15 years ago. Horace Gooch, Jr., chairman of the board, also was re-elected for a second year. J. E. Gould was elected vice-president, and John J. O'Connell, secretary-treasurer.

Consolidated Engineering Corporation Subsidiary. The formation of a new corporation, CEC Instruments, Inc., as a subsidiary organization to handle sales and service work on instruments manufactured by Consolidated Engineering Corporation, Pasadena, Calif., was announced recently. Direct consultation and efficient service on Consolidated's line of instruments will be the main objective of CEC Instruments, Inc. Because of the increase in production of its instruments, the company felt the need for an organization of qualified engineers who could cope with the application and operational problems of individual clients and would be more quickly available than when routed from the Pasadena office.

Officers of the new company will be Philip S. Fogg, president; James B. Christie, secretary; Hugh F. Colvin, treasurer; and Robert L. Smallman and Harold F. Wiley, vice-presidents. Main office of CEC Instruments, Inc., will be at the Consolidated plant at 300 North Sierra Madre Villa, Pasadena. All new offices have not been announced yet but those already in operation are in New York, N. Y.; Philadelphia, Pa.; Dayton, Ohio; Chicago, Ill.; and Washington, D. C.

NEW PRODUCTS • •

Equation Solver. The Lineac, an electric analogue computer for the solution of linear simultaneous algebraic equations, both scalar and complex, has been developed by the American Hydromath Corporation, New York, N. Y. It uses no amplifiers and has the outstanding feature that the solution is obtained immediately without any iterative process, either manual or automatic. It may be used in reverse for the simulation of linear functions, that is, functions which are the sum of a number of terms each of which is the product of a variable and a constant. It consists essentially of multicoil tapped transformers and a voltage divider and operates on 60-cycle voltage. For well-conditioned matrices of the order of 10 or so the error is a fraction of one per cent, and this accuracy can be extended to considerably higher orders by the use of simple compensating adjustments. The Lineac's basic components are nonprecision transformers and rheostats.

High-Current Resistor. Powr-Rib, a new edge-wound-type resistor, designed for high-current duty in both intermittent

(Continued on page 32A)

Where lights
must be kept burning,
specify
SILASTIC*
lead wire

In the chemical industry where lights, essential to the safety of working men, burn 24 hours a day; along the runways of airports; in railway yards and control towers; along the docks and in beacon lights off-shore; Silastic-covered lead wire can assure continuous, trouble-free operation, and pay for itself in reduced maintenance and replacement costs alone. ¶ In the huge Midland plant of The Dow Chemical Company, for example, all lighting circuits are carried in conduit that doubles as supports and hangers for more than 50,000 lighting fixtures. Many of these are vapor-proof or explosion-proof fixtures where heat is a more serious problem. Over half of these fixtures burn constantly. Most of them are exposed to outdoor weathering. ¶ Under those conditions, maintenance and replacement were such a costly problem that engineers in the Electrical Department tried, and now specify, lead wire insulated with Silastic. This Dow Corning silicone rubber is the only kind of rubbery insulating material that retains good dielectric properties and will not crack or become brittle after long and continuous exposure to outdoor weathering at temperatures from —70° to +350° F. ¶ Silastic is also used as a gasketing and sealing material in hundreds of aircraft and automotive applications, at temperatures ranging from —100° to more than +500° F. It is unique among electrical insulating materials for Class B and Class H lead wire, for ignition and Navy control cable, and for transformers and field coils in traction motors.

Put Silastic to work for you; mail this coupon to:

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Midland, Mich.
Please send me:
☐ Silastic Facts 10a with new data on properties and applications of all Silastic stocks and pastes.
☐ "What's A Silicone?", your new 32-page booklet on silicone products and applications.
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Title____________________
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City__________Zone____State____

*T.M. Reg. U.S. Pat. Off.

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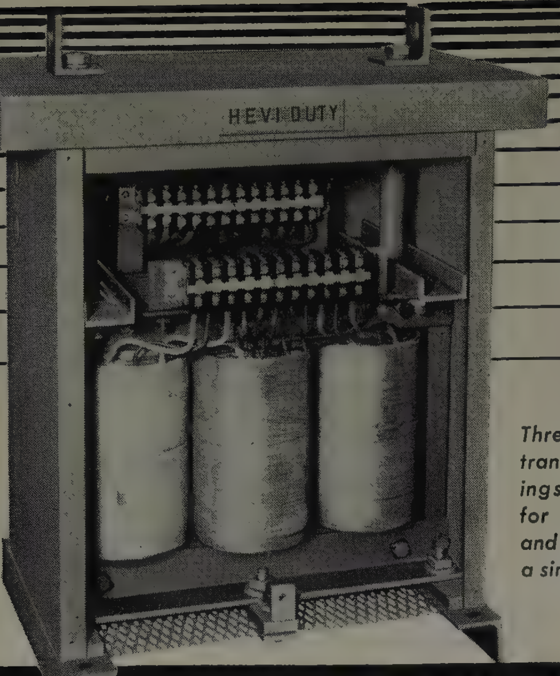
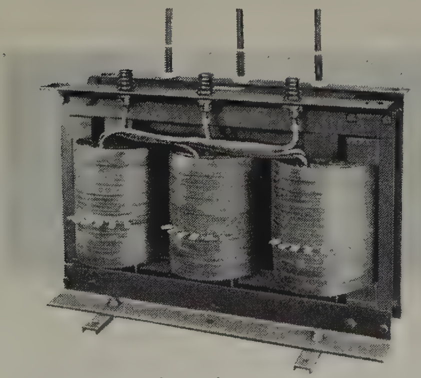
Atlanta • Chicago • Cleveland • Dallas • New York • Los Angeles • Washington, D. C.
In Canada: Fiberglas Canada Ltd., Toronto • In England: Midland Silicones Ltd., London



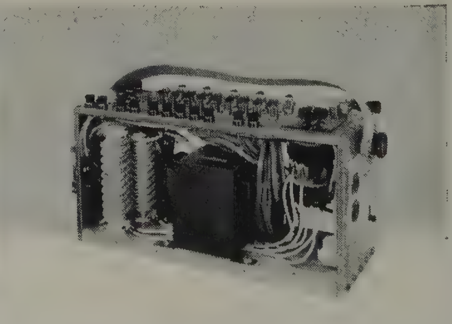
Three phase rectifier transformer, providing separate windings for control, filament and plate supply as a single unit.

HEVI-DUTY® DRY TYPE Specialty TRANSFORMERS

Here are three typical examples of transformers that have been designed by Hevi Duty engineers for specific applications. Whether your needs are large or small for either standard or special transformers, you can depend on the engineering skill and modern manufacturing facilities of Hevi Duty Electric Co. to serve you.



Open type three phase insulating transformer for installation in control center cubicles. Primary voltages to 15 KV are available.



Hevi Duty, 3 KVA type S10 transformer is part of a portable test box used by electric utilities for testing protective relays in the field.

HEVI DUTY ELECTRIC COMPANY
MILWAUKEE 1, WISCONSIN
Heat Treating Furnaces . . . Electric Exclusively
Dry Type Transformers Constant Current Regulators

(Continued from page 28A)

and continuous applications, has been announced by the Ohmite Manufacturing Company, Chicago, Ill. The new resistor offers high heat dissipation, resistance to oxidation, and the ability to withstand shock and vibration without breaking or short-circuiting. They are wound with a heavy ribbon of resistance alloy on a ceramic insulator. All other metal parts are specially plated to prevent oxidation at high operating temperatures and to provide good electrical contact. The ceramic insulator is divided into five sections to give the required flexibility and resistance to shock and vibration. On the mounting bar of the new resistor is a longitudinal slot allowing the mounting center to vary between 16¼ and 17 inches. Thus the unit is able to replace any standard edge-wound resistor. Ohmite Powr-Rib resistors are available in resistance values from 0.100 to 2.85 ohms. They are rated at 375 degrees centigrade temperature rise on the ribbon. Full-rated capacities range from 18.0 to 108 amperes. Further details are available from Ohmite Manufacturing Company, 4823 Flournoy Street, Chicago, Ill.

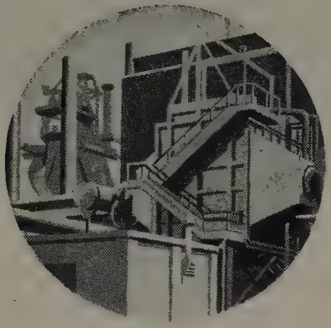
Instant Safety Cutoff. A new portable mining machine cable which reduces the chance of shock hazard and arcing when a break occurs has just been developed for Anaconda Wire and Cable Company, New York, N. Y. The purpose of this cable design is to cut off the power the instant damage occurs to the positive conductor insulation. The cable is used in conjunction with a ground trip relay which, when energized, shuts the power off. It is especially adaptable for use with shuttle cars and other mobile mining machines.

Direct-Voltage-Measuring Reactor. A new direct-voltage-measuring reactor, to provide increased safety in the measurement of direct voltage by insulating the instrument circuit from the power source, has been announced by the General Electric Company, Schenectady, N. Y. Developed for remote measurements of direct voltages up to 1,200 volts, the equipment consists of a saturable core reactor with a single d-c winding, two a-c windings, and proper range resistors. The d-c winding has a saturating effect on the core, and the a-c windings, supplied from a separate power source, deliver a rectified average current proportional to the degree of saturation of the core. A selenium bridge rectifier is used in the a-c circuit to permit interpretation of the average current. A calibrating adjustment is provided with the new device which permits final adjustment of the output current to the burden used. The reactor is designed to work into a burden with a nominal resistance of 25 ohms. The burden should not exceed a maximum resistance of 100 ohms. The direct-voltage-measuring reactor has a plus or minus accuracy of 0.5 per cent of full scale and operates on a power supply of 115 volts, 60 cycles.

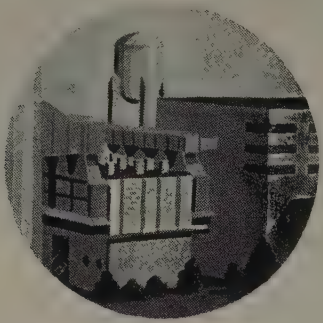
(Continued on page 36A)

War on waste!

American industry is continually searching for new ways to stop waste and increase production and efficiency. A good example of this is the Koppers-Elex electrostatic precipitator. Shown below are a few typical ways industry uses them to combat waste . . .



BLAST FURNACE GAS must be cleaned before it can be used as a fuel. Koppers-Elex electrostatic precipitators clean this gas to residuals as low as .002 grain per cubic foot.



FLUE GASES from recovery boilers in pulp mills contain valuable materials. Koppers-Elex electrostatic precipitators recover several hundred thousand dollars worth of these materials yearly.

FLY ASH from power plants and factories may drop a blanket of dust extending three to five miles. Koppers-Elex electrostatic precipitators stop this nuisance and preserve public good will.

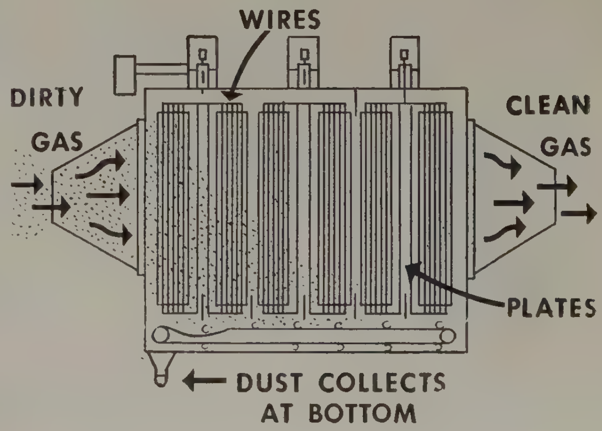
Guaranteed: All Koppers-Elex electrostatic precipitators are guaranteed to equal or better (under tests made by your own personnel) any efficiency or residual content you specify.

ENGINEERS! You should know about these six design features of Koppers-Elex electrostatic precipitators!

KOPPERS has made sweeping improvements in electrostatic precipitator design! For example, double chambers eliminate expensive by-pass systems and the resultant loss of materials during inspection or maintenance. And re-entrainment is sharply reduced because rapping is sectionalized.

Successive collection zones are separately energized to provide maximum voltage for highest collection. And because each field is, in effect, a separate precipitator, the outage of one field *does not stop* gas-cleaning action. In addition, completely enclosed and compact "package" mechanical or vacuum tube power packs simplify installation and operation.

Another exclusive Koppers feature is the drag scraper which provides continuous dust removal, eliminates plugged hoppers and prevents bothersome dust build-up. For detailed information on recovery, gas-cleaning or nuisance abatement results write today to: Koppers Company, Inc., Precipitator Dept., 238 Scott Street, Baltimore 3, Md.



If you have a gas-cleaning problem, write today to: Koppers Company, Inc., Precipitator Dept., 238 Scott St., Baltimore 3, Md.

KOPPERS

Koppers-Elex ELECTROSTATIC PRECIPITATORS

"Wonder drugs" for ailing contacts

New metal powder combinations are the "wonder drugs" for treating electrical contact ills.

Molded silver-graphite quickly cures chronic cases of premature contact failure.

Silver-tungsten, silver-iron oxide, copper-graphite, silver-lead oxide and various others work wonders in other instances.

But "wonder drugs" themselves are only part of the story!

Very often, improvement depends as much on the way these contact materials are produced as on the materials themselves. Contacts of identical metallic composition may be given widely different properties. Stackpole "know how" in achieving desirable properties accurately is, we believe, equally noteworthy to the Stackpole pioneering of various contact "wonder drugs" or the Stackpole facilities for producing them all.

STACKPOLE CARBON COMPANY, *St. Marys, Pa.*

Helpful Contact Data

Stackpole Bulletin 12 contains a wealth of helpful data on modern contact materials and their uses.

STACKPOLE

ALL CONTACT SHAPES AND SIZES IN SILVER-GRAPHITE • SILVER-LEAD OXIDE SILVER-IRON OXIDE • SILVER-NICKEL • SILVER-MOLYBDENUM SILVER-TUNGSTEN • COPPER-GRAPHITE • COPPER-TUNGSTEN COPPER MOLYBDENUM *and various other materials.*

(Continued from page 32A)

Right-Angle Worm-Gear Motor. An entirely new line of low-speed right-angle worm-gear motors has been placed in production by U. S. Electrical Motors, Los Angeles, Calif. Introduced as Type *GW* Syncrogear, the design presents numerous exclusive features not before available in low-speed motors. Type *GW* incorporates a cantilever design to protect gear alignment. Mounting stresses are absorbed by a single unit pyramidal base. The gear and motor housing are free from distortion. It embodies splash lubrication, a hardened and ground worm, leakproof oil seal, and asbestos-protected windings. It has self-locking brake action. This new motor is built in speed ranges from 1/4 to 3. It is made in both 3 phase and single phase, can be installed horizontally or upright, and can be provided with a footless flange mounting. Other modifications provide variable speed, splashproof design, and total enclosure. Full details are available from the manufacturer.

Omniometer. The Omniometer is a new, single, all-purpose instrument for the measurement of radiation developed by the Radiation Counter Laboratories, Inc., Skokie, Ill. It may be employed with all types of sensing elements which are now in general use such as Geiger, proportional, and scintillation counters. The internal structure of the Omniometer follows the basic principles developed at Oak Ridge National Laboratory. It incorporates two high-voltage supplies which provide overlapping voltage ranges from 500 to 5,000 volts. Changeover can be accomplished by a simple switch. If the sensing elements deliver 1/4-volt pulses or higher, then access is direct to the scaling circuit. For counting apparatus delivering voltage pulses of smaller magnitude, the pulses are fed into the amplifier input, and then to the scaler. This scaler has a variable scaling factor of 64, 128, 256, and 512 which enables the user to utilize high counting rates and fast detectors. The counting switch automatically actuates a built-in timer which gives the time interval necessary to accumulate the desired number of counts.

Special Waveform Generators. Tektronix, Inc., has developed a series of instruments, the Type *160* Regulated Power Supply, the Type *161* Pulse Generator, and the Type *162* Waveform Generator, to fill the need for a source of precision waveforms with controllable characteristics. The Type *160* Regulated Power Supply is capable of supplying the necessary alternating and regulated direct voltages to operate six of the other two units in combination. It is completely regulated to compensate for line-voltage fluctuations over the range of 105 to 125 volts, and for changes in load. The Type *161* Pulse Generator supplies rectangular pulses of known and variable amplitude and duration, of either positive or negative polarity. A positive gate of the same

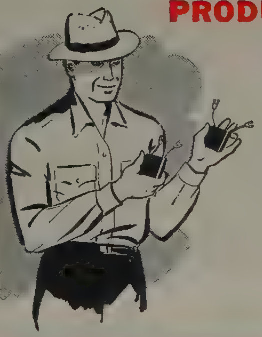
(Continued on page 38A)

NATIONAL
CARBON BRUSHES
FOR UNIFORMITY · DEPENDABILITY
NATIONAL
TRADE-MARK
CARBON BRUSHES
DESIGNED AND BUILT SPECIFICALLY
FOR EFFICIENT.... UNINTERRUPTED
MOTOR AND GENERATOR OPERATION

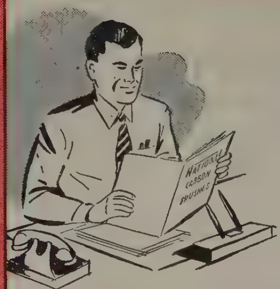
Customers TELL US about NATIONAL Standardized Brushes!

TRADE-MARK

STANDARDIZATION of industrial motor brushes means different things to different people. But no matter how they define it, National Carbon's pioneer brush-standardization program is making their jobs *easier,* helping them do *better* work, *saving* their company *time* and *money.*



PRODUCT—"Practically every machine and part in this plant is *standardized,*" said one Chief Electrician. "Why not brushes, too? The quality of our own products is constantly being improved through standards procedure." **HE'S RIGHT!** Brushes are no exception to the rule that volume production of *standard* items results in greater uniformity, closer control of materials and processes.



PRICE AND DELIVERY—"Standardization?" said this Purchasing Agent. "If that's what's behind your FLAT PRICE deal, I'm for it! I don't have to worry about quantity discounts and your on-the-button deliveries take a real headache out of inventory!"

HE'S RIGHT, TOO! Standardized brushes are mass-produced *for* stock... shipped *from* stock at the same low, FLAT price for 100 or 100,000 brushes!

PACKAGE—"You wouldn't believe how many different ways brushes are packed," one Stores Keeper told us. "Bags, barrels, boxes of every size and shape. But National Carbon's *standardized* cartons are tops. They pack neat, stack straight, are clearly marked and keep their shape."

RIGHT AGAIN! Mass production enables us to deliver a better package in a minimum number of carton sizes.

LOW LIGHT BILLS... mark phenomenal acceptance of "EVEREADY" No. 1050 Industrial Flashlight Batteries by a broad cross-section of industry. Delivering *twice the usable light* of any battery we've ever made before, it will not swell, stick or jam in the flashlight... has no metal can to leak or corrode.

No. 1050
EVEREADY
WILL NOT SWELL, STICK OR JAM IN FLASHLIGHT

Write for Bulletin CP-2426
"NATIONAL" STANDARDIZED BRUSHES

"NATIONAL" STANDARDIZED BRUSHES

BETTER—PRODUCT—PACKAGE—PRICE—FASTER

The terms "National", "Eveready" and the Three Pyramids device are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N.Y.

District Sales Offices:
Atlanta, Chicago, Dallas, Kansas City,
New York, Pittsburgh, San Francisco

In Canada:
NATIONAL CARBON LIMITED
Montreal, Toronto, Winnipeg

BUILT BY Standard
TRADE MARK ®
FOR A SPECIAL NEED . . .

DESIGN — Engineers have found that time is saved by using Standard's design service whenever they specify transformers for use in special projects. Long design experience on transformers for all needs, including power, distribution, metering and testing, is at your service.

MANUFACTURING — Standard's methods are set up for quality production . . . many functions ordinarily left to mass methods are performed by specialists and skilled mechanics who do custom work. Specifications established by ASA are met or exceeded. Job proved products are your assurance of complete satisfaction.

● Get acquainted with The Standard Transformer Company. Be sure Standard's booklet CL-50-EE is in your files.

OFFICES IN PRINCIPAL CITIES

THE Standard
TRADE MARK ®
TRANSFORMER CO.
WARREN, OHIO
(Exclusively transformer designers and manufacturers)

TRANSFORMERS FOR EVERY APPLICATION

Liquid filled (sizes up to 10,000 KVA and 72 KV inc.)

Instrument transformers (for use on circuits up to 72,000 volts, inc.)

Dry type (up to 1000 KVA and max. voltage ratings of 4800)

Control transformers (compound filled or open type)

(*Continued from page 36A*)

duration as the pulse, and a delay facility are available. The Type *162* Waveform Generator provides a linear sawtooth waveform, a positive gate, and a positive trigger. The operation can be gated, triggered, or recurrent, and also can be controlled by a push button, remote or on the panel. A power supply and six units fit into two $12\frac{1}{4}$-inch by 19-inch standard relay racks, by means of special mounting frames.

Embedded Selenium Rectifiers. The Rectifier Division of Sarkes Tarzian, Inc., Bloomington, Ind., is producing embedded selenium rectifiers designed to meet all specifications on environmental conditions, shock, acceleration, and high-altitude operation in military equipment. Additional information may be obtained from the company.

Neon Indicating Fuseholder. The New Products Division of the Alden Products Company, Brockton, Mass., has announced a neon indicating fuseholder, the Alden Fuselite *440-5FH.* A compact, panel-mounting fuseholder, the Fuselite takes a standard 3 *AG* or 3 *AB* fuse. A unique feature is the integrally molded neon bulb in a crystal-clear plastic lens that lights up instantly when the fuse blows. This feature is important in helping to locate the source of trouble quickly and in reducing fuse replacement time to a minimum. The *440-5FH* has practically universal application in 110-volt circuits. With slight modifications it can be used for 220 volts. Additional information can be obtained from the manufacturer.

Pressurizing Kit. The Romec Division, Lear, Inc., Elyria, Ohio, has developed Model *RR-9500B* Pressurizing Kit for pressurizing ground radar installations and related electronic equipment. It contains complete instrumentation and automatic controls necessary for supplying dry, oilless air at elevated pressure without interruption over long unattended periods. Servicing of the unit is facilitated by the inclusion of a spare air filter-dehydrator, which can be inserted in a few seconds. No lubricant is used in the air compressor. Actual sea level capacity is 1.0 cubic feet of free air per minute. Compressor is approved for use in extreme temperatures to −65 degrees Fahrenheit. The unit requires 120-volt 400-cycle electric power. The intermittent operation of the air compressor is controlled by a pressure switch. A light on the panel indicates when the pump is running. The switch pressure adjustment is located just above the light and may be set to any pressure within the range of the 0 to 20 pounds per square inch pressure gauge. For complete information write R. S. Atkinson, Lear, Inc., Romec Division, Elyria, Ohio.

Industrial Forced-Air Electric Heater. A forced-air 440-volt electric heater for industrial use has been developed by the Kilbury Manufacturing Company, Lawndale, Calif. It is a complete heating

(*Continued on page 50A*)

Isomica is a built-up electrical insulating material made with thin, coherent, homogeneous, continuous sheets of mica paper (marketed under the trade name Samica), which are coated with organic or inorganic silicone binders, and cured under heat and pressure. The result is *Isomica*.

Isomica is more uniform in weight and thickness than built-up mica made with mica splittings. It has substantially higher minimum dielectric strength, and it does not chip or flake.

Extremely Versatile

Isomica can be made in the form of sheets, tubes and tapes, as well as formed parts made to your specifications. By modifying the kind and quantity of binder, as well as the degree of cure, it can be produced in various types or grades to meet your specific electrical insulation needs.

Many types of specialty mica insulation which cannot be produced successfully with mica splittings *can* be made with *Isomica*. Most types of built-up mica products now using splittings can be *improved* with *Isomica*.

It may well be the answer to *your* electrical insulation problems. Let us put our 58 years of experience in this field at your service.

Write for Information

Descriptive literature is available, and will be supplied promptly on request. Samples of various types of *Isomica* will be furnished gladly for test purposes. Write us today...on your company letterhead, please.

Applications of Typical Isomica Parts

(In Class H or Class B motors, generators, transformers, etc.)

FLEXIBLE MATERIAL and TAPES
- Slot liner, core and ground insulation.
- Phase to phase insulation.
- Phase and end-winding insulation.
- Primary-secondary separation.
- Coil exteriors and cable splices.
- Coils, cable and cell wrapper tapes.

MOLDED PARTS
- Formed parts of various shapes.
- Commutator Vee rings and cones.
- Slot cells and troughs.
- End-bell insulation.
- Coil forms and spools.
- Tubes of varying cross section for terminals, bars, etc.
- High tension terminals and barriers.
- Angles and bushings.

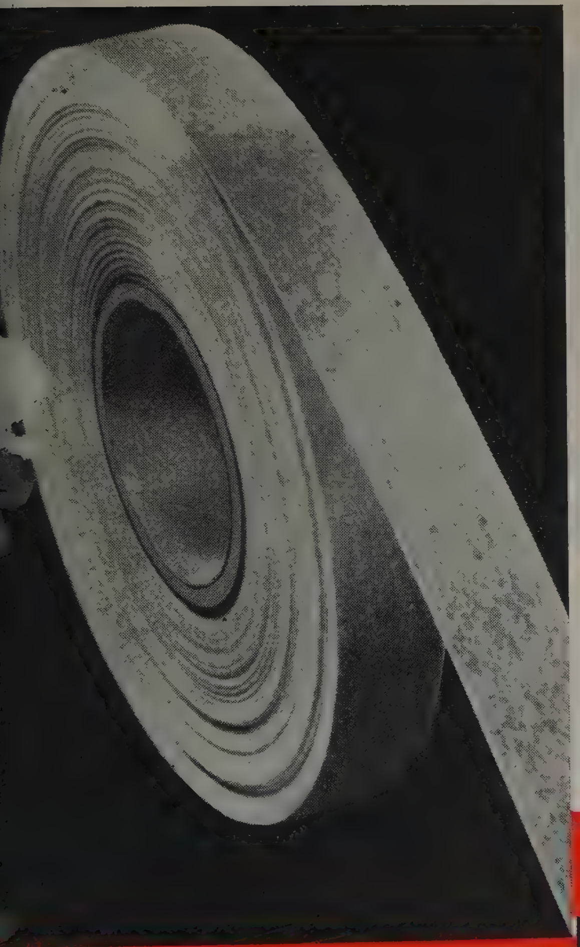
SEGMENT PLATES
- Variously shaped flat parts subjected to heat and pressure.
- Commutator segments.
- Barriers, washers and discs.

MICO ELECTRICAL INSULATION

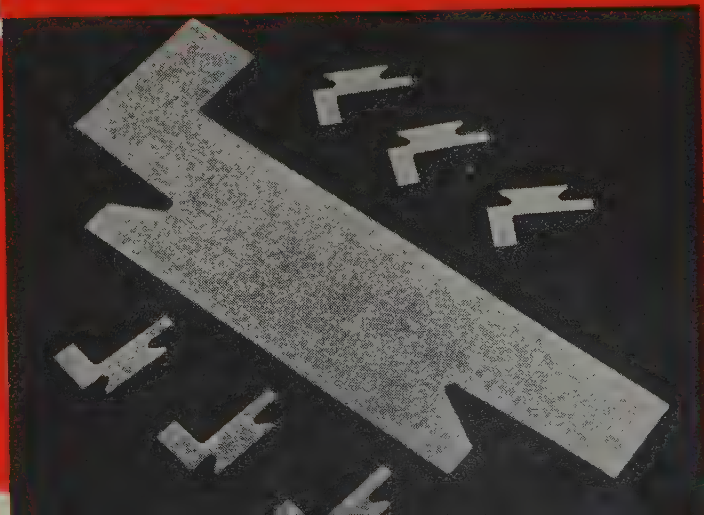
MICA *Insulator* COMPANY

Schenectady 1, New York

Offices in Principal Cities

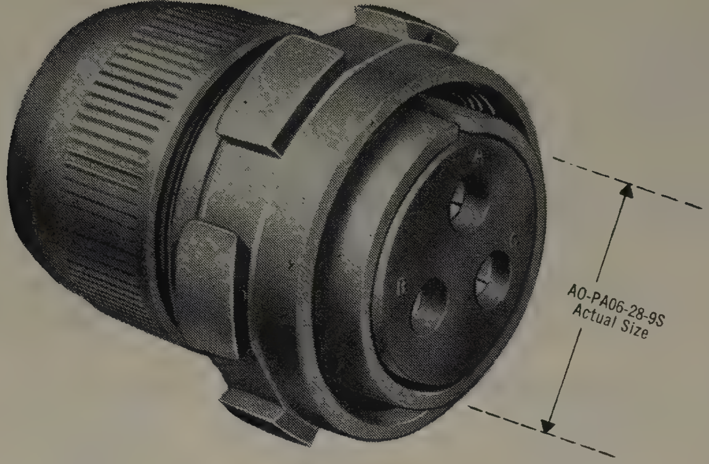


ISOMICA TAPE: This new Isomica tape can be run on taping machines at high speeds. The tapes have no low spots or voids . . . always show much higher minimum dielectric strength than mica splitting materials of the same thickness.



ISOMICA SEGMENT PLATE: Armature assembly is easier with smooth, uniform, homogeneous Isomica segments. They allow accurate fabrication . . . the danger of sliding of the mica or oozing of the binder during commutator assembly is substantially decreased.

CANNON PLUGS to ARMY ORDNANCE specification

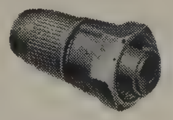


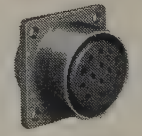
AO Cannon Type AO Series connectors are manufactured under the latest specification pertaining to electrical systems for military vehicles and associated external electrical equipment. "AO" connectors will mate with standard "AN" fittings. Are ideal for heavy duty industrial use.

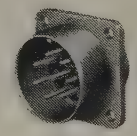
This new series is designed to withstand extreme conditions of temperature, moisture, dust, vibration and shock. Shell material is aluminum alloy with natural iridite finish. Insulators are of a special molded resilient material having high dielectric strength, medium oil resistance and will not support combustion. Resilient grommet provides moisture proofing over solder terminals.

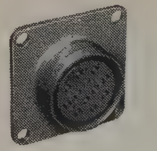
For engineering data, request Bulletin AO-1952.

SOCKET INSERT ASSEMBLY TYPE AO-RA00 WITH GROMMET RETAINING NUT


TYPE AO-PA06 WITH GROMMET RETAINING NUT


SOCKET INSERT ASSEMBLY TYPE AO-RB02

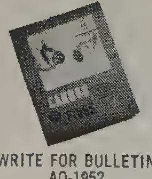

PIN INSERT ASSEMBLY TYPE AO-RB02


AO TRAILER RECEPTACLE

DUST CAP

AO SLAVE RECEPTACLE

TYPE AO-22 ANGLE 90° ELBOW


WRITE FOR BULLETIN AO-1952

CANNON ELECTRIC
Since 1915
Factories in Los Angeles, Toronto, New Haven, Benton Harbor. Representatives in principal cities. Address inquiries to Cannon Electric Company, Dept. H-117 P. O. Box 75, Lincoln Heights Station, Los Angeles 31, Calif.

(Continued from page 38A)

plant in a small package about 2 feet square and weighs approximately 100 pounds. Rated at 13.1 kw, it develops a heat output of 45,000 Btu and is suitable for heating small shops or may be used for processing applications or as a portable heater for spot heat. In combination of multiple units it will take care of heating large plants when used for zone, perimeter, loading dock, auxiliary, or supplemental heat. Equipped with automatic temperature controls and built-in-safety switches and fuses, the electric heater requires only a suitable power supply to operate. The heater consists essentially of ceramic core heating elements, 115-volt motor-operated blower, and associated control equipment. The control circuit is comprised of a 440/115-volt transformer, 115-volt thermostat, gang of micro switches operated by means of a solenoid, high-temperature cutout, circuit breaker to protect primary winding of transformer, and fuses to protect motor and solenoid. Blower moves 300 cubic feet of air per minute at 1,500 feet per minute speed.

Engine-Driven Welder. A new lightweight engine-driven welder, Type *EW-20*, is available from the Westinghouse Electric Corporation, Pittsburgh, Pa. Equipped with complete engine accessories and auxiliary apparatus, the new welder also can supply 110-volt 60-cycle single-phase power from a conventional plug-in outlet. Nominal rating of the welder is 200 amperes, 40 volts, 60-per-cent duty cycle, with current range from 40 to 250 amperes in accordance with National Electrical Manufacturers Association standards. During off-welding periods, auxiliary power of 3 kw at 100-per-cent power factor or 2 kva at 80-per-cent power factor are available for lights and power tools. During welding periods about 300 watts auxiliary power is available for lights. Coupled to a Ford 120 4-cycle 4-cylinder water-cooled industrial power unit, the self-excited compound-wound generator functions both as a d-c generator and a single-phase alternator for auxiliary power. Welding power is controlled in four ranges by a tap switch and shunt field rheostat. The a-c power circuit includes conventional outlets, a voltmeter, and a circuit breaker with overload protection. For further information write Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

TRADE LITERATURE

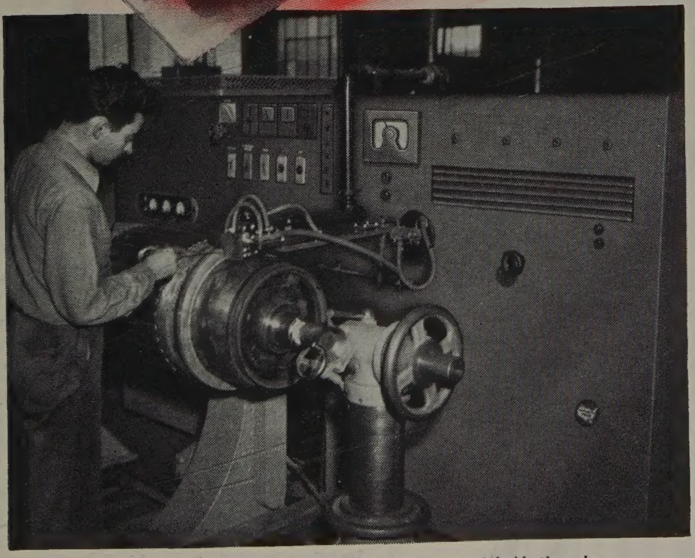
Lectrodryer Bulletin. A 32-page bulletin "Because Moisture Isn't Pink," has been published by Pittsburgh Lectrodryer Corporation, Pittsburgh, Pa. It tells how dehumidifying equipment solves moisture problems for industry. Illustrated by 70 photographs and diagrams of actual installations, the bulletin describes many production, handling, and storage problems

(Continued on page 56)

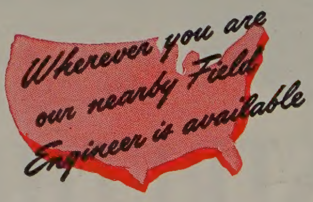
SOLDERING ARMATURE COIL LEADS

without a Soldering Iron?

Soldering armature coil leads to risers by hand leaves a lot to the human element. So three years ago, National developed a way to solder by induction heating. It's quicker. More uniform. *Reduces liability of premature trouble.* If you've wondered why a motor or generator repaired or redesigned by National gives such excellent service . . . it's the "little" things like this which National does, unheralded and unsung, that count so much. They mean a lot *in the long run.* Use National coils and engineering service for the unannounced advances which add so little to cost, so much to value.



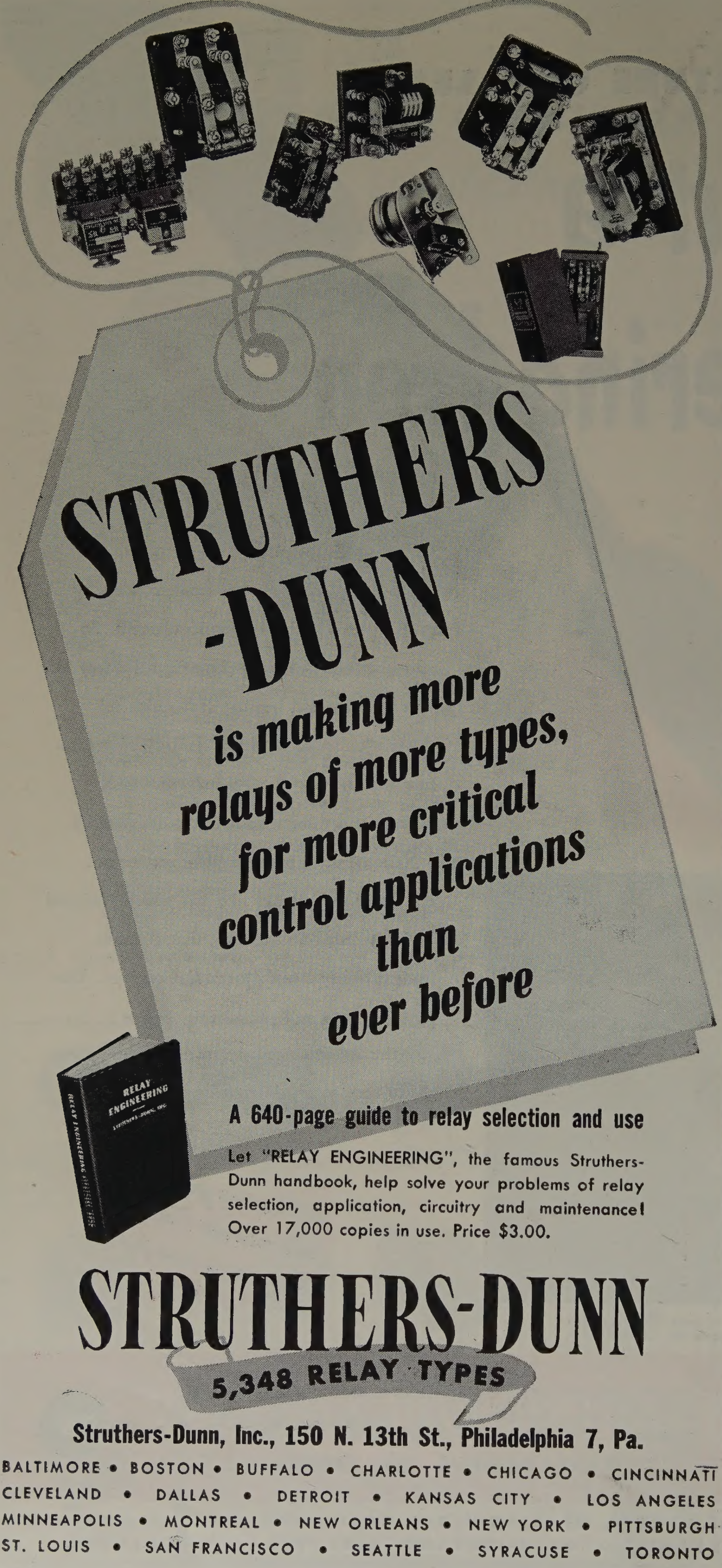
Soldering armature coil leads to risers with National-designed induction heating equipment in the National plant.



NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A. TRADE MARK

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES



STRUTHERS-DUNN is making more relays of more types, for more critical control applications than ever before

A 640-page guide to relay selection and use

Let "RELAY ENGINEERING", the famous Struthers-Dunn handbook, help solve your problems of relay selection, application, circuitry and maintenance! Over 17,000 copies in use. Price $3.00.

STRUTHERS-DUNN

5,348 RELAY TYPES

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BALTIMORE • BOSTON • BUFFALO • CHARLOTTE • CHICAGO • CINCINNATI
CLEVELAND • DALLAS • DETROIT • KANSAS CITY • LOS ANGELES
MINNEAPOLIS • MONTREAL • NEW ORLEANS • NEW YORK • PITTSBURGH
ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

(Continued from page 50A)

that were solved successfully by installing Lectrodryers. The bulletin, number 222, is available free from Pittsburgh Lectrodryer Corporation, P. O. Box 1766, Pittsburgh, Pa.

Electrical Insulating Varnishes. Information on varnish selection and use has been incorporated into a 20-page catalogue issued by Insulation Manufacturers Corporation, Chicago, Ill. Varnish composition, types, functions, colors, processing, and care are covered by this literature. This completely illustrated catalogue may be obtained free of charge by writing to the Publications Department, Insulation Manufacturers Corporation, 565 West Washington Boulevard, Chicago, Ill.

Tool and Die Salvage Welding. The fourth of a series of "How-to-Weld-It-Better" Manuals, "Tool and Die Salvage Welding," a 64-page, illustrated book on latest welding developments and techniques in this field, is being offered by Eutectic Welding Alloys Corporation, Flushing, N. Y. Over 100 photographs, drawings, charts, and diagrams are devoted to a detailed discussion of more efficient and more widespread usage of improved tool and die welding procedures. Copies may be obtained without charge upon request to Eutectic Welding Alloys Corporation, Department P, 172 Street at Northern Boulevard, Flushing 58, N. Y.

Standard Die Catalogue. A 32-page Standard Die Catalogue, designed for quick reference, has been issued by Federal Machinery Company, New York, N. Y. Compiled to facilitate ordering of standard punches and dies of various types for hand, foot, and power presses, the catalogue is complete with detailed diagrams, charts, tables, and illustrations of typical machinery and equipment. Prices are shown alongside each item discussed. Also illustrated and described are punch adaptors, die adaptors, and die shoes. Copies are available upon request to Sales Department, Federal Machinery Company, 134 Grand Street, New York, N. Y.

Pressure-Sensitive Tapes. Two dozen "Scotch" brand pressure-sensitive tapes that meet various government specifications are described in a new 16-page manual announced by Minnesota Mining and Manufacturing Co., St. Paul. The new manual, available on request, contains 42 photographs and illustrations, and gives complete data on tapes for packaging, holding, mending, masking, sealing, mounting, protecting, insulating, and splicing jobs. In addition, the manual lists 11 tapes for the construction and maintenance of electric and electronic equipment, plus two magnetic recording tapes for such jobs as telemetering, computing, and industrial training programs.

Wheelco Data Book and Catalogue. The new 42-page 1952 edition of the Wheelco

(Continued on page 62A)

HERE'S YOUR PROOF OF . . . .

DRAVO *Counterflo* HEATER VERSATILITY!

DRAVO *Counterflo* HEATER
CASE STUDY REPORT

POTTERY
Plant Output
Doubled by
Improved Process
Drying System

User W. A. CASE & SON MFG. CO.
Location ROBINSON, ILL.
Products VITREOUS CHINA SANITARY WARE

Dravo Counterflo Heaters in use at time of case study — NUMBER 4 — FUEL GAS & OIL — OUTPUT (Btu) 1,500,000 Each

for PROCESS DRYING
and HEAT CURING

DRAVO "*Counterflo*" HEATER
CASE STUDY REPORT

TUBING MANUFACTURER
Saves $12,000 a Year
in Annual
Operating Costs

User LINDERME TUBE COMPANY
Location EUCLID, OHIO

Dravo "Counterflo" Heaters in use at time of case study — NUMBER 7, 1, TOTAL 8 — FUEL HEAVY OIL, HEAVY OIL — OUTPUT (Btu) 1,000,000

Function of Heaters — To provid

for COMFORT HEATING of
LARGE BUILDING AREAS

get these
FREE case
studies now!

Detailed information and photographs show how heaters can be adapted for process drying and heat curing . . . or how large open spaces in commercial, industrial or educational buildings can be comfortably, easily and quickly heated with Dravo Heaters. These case studies give you proof of Dravo Heater versatility, and they're yours for the asking.

DRAVO HEATERS OFFER YOU:

LOW INITIAL COST—Users report 30% to 60% savings over "wet-type" systems.

EASY INSTALLATION—Need only fuel, exhaust and electrical connections . . . no ductwork.

LOW OPERATING COST—Direct-fired . . . burn gas or oil . . . readily converted . . . minimum efficiency 80%.

AUTOMATIC OPERATION—On-off or modulating controls . . . no constant attention needed.

LONG SERVICE LIFE, LOW MAINTENANCE—Stainless steel combustion chamber eliminates refractory lining.

SAFETY—Approved by American Gas Association, listed by Underwriters' Laboratories, Inc.; Dravo standardized safety control circuit accepted by Factory Mutual Engineering Division.

MOBILITY—Can be moved to any location.

FLEXIBILITY—When floor space is limited, can be wall-hung or suspended from trusses in any position.

DRAVO
CORPORATION

PITTSBURGH • ATLANTA • BOSTON • CHICAGO • CINCINNATI
CLEVELAND • DETROIT • NEW YORK • ST. LOUIS • PHILADELPHIA
WASHINGTON

Sales Representatives in Principal Cities

Manufactured and sold in Canada by Marine Industries, Ltd., Sorel, Quebec. Export Associates: Lynch, Wilde & Co., Washington 9, D.C.

DRAVO HEATERS SOLVE HEATING PROBLEMS
IN THESE INSTALLATIONS, TOO:

- **TEMPERING MAKE-UP AIR**—where removal of noxious fumes makes comfort heating normally difficult.
- **TEMPORARY HEATING**—where comfort heat is necessary during building construction or to keep ground temperature above freezing in winter.
- **HEATING AND VENTILATING STORES, SCHOOLS AND AUDITORIUMS**—where quick, automatically controlled, low-cost heating is desired.

FOR FREE CASE STUDIES OF INTEREST TO YOU
MAIL THIS COUPON TODAY . . .
(Case Study sheets are 8½" x 11", punched for binder or convenient filing.)

HEATING DEPARTMENT, DRAVO CORPORATION
Dravo Building, Fifth and Liberty Avenues
Pittsburgh 22, Pa.

DRAVO

Please send me the following case studies FREE:

☐ Process drying and heat curing
☐ Space heating large buildings
☐ Tempering make-up air
☐ Temporary heating
☐ Stores, schools and auditoriums
☐ Please have a representative call.

Name____________________Title____________

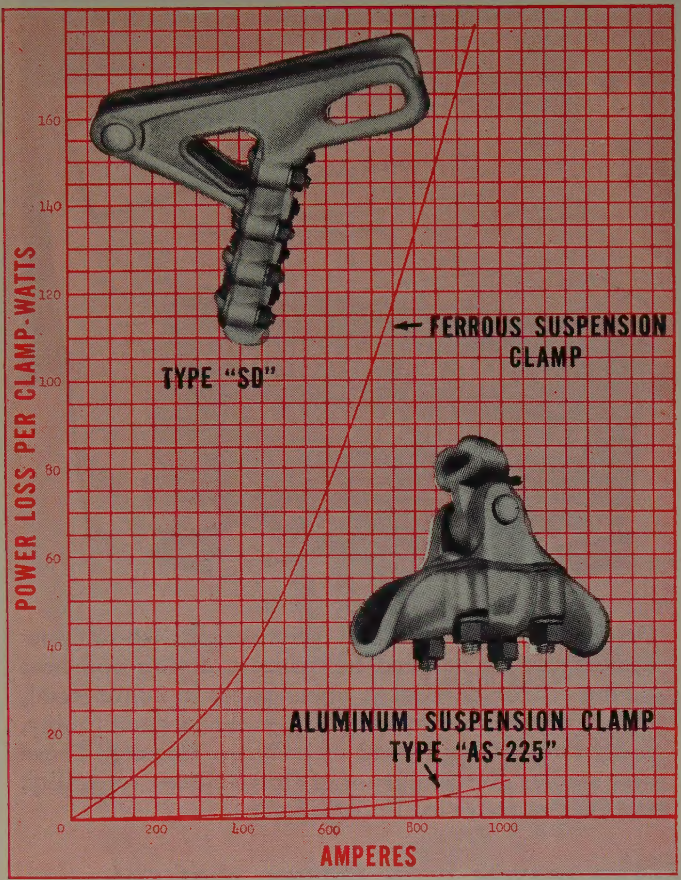
Company______________________________

Address______________________________

City________________Zone_____State________

When writing ask for Bulletin DE-523-13

MORE POWER
DELIVERED WITH LESS MAINTENANCE . .



Backed by many years of coordinated electrical, mechanical and metallurgical engineering knowledge and experience in the design and manufacture of cast aluminum products for the electrical industry.

USE CAST ALUMINUM
TYPE "AS" SUSPENSION AND TYPE "SD" STRAIN CLAMPS
ON ALUMINUM TRANSMISSION LINES

STOP—Hysteresis and eddy current power losses.

PREVENT—Corrosion, heating and annealing damage to conductor within clamps.

ELIMINATE—Jumper splice failures—use through conductor strain clamps with continuous jumpers at strain points.

BE SURE—SPECIFY—Cast aluminum clamps with more than 25% greater strength.

WRITE FOR
Catalog No. 320

Consult one of our nearest 18 representatives or contact our main office.

OUR PRODUCTS ARE QUALITY CONTROLLED
FROM INGOT TO FINISHED PRODUCT

ABW

Anderson Brass Works, Inc.
POST OFFICE DRAWER 2151
Birmingham, 1, Alabama

• BRONZE AND ALUMINUM POWER CONNECTORS, FITTINGS, AND BUS SUPPORTS
ALUMINUM SUSPENSION AND STRAIN CLAMPS

(*Continued from page 56A*)

Data Book and Catalogue containing up-to-date prices, application recommendations, and pertinent information concerning instrument sensing units and associated accessories has just been released by the Wheelco Instruments Division, Barber-Colman Company, Rockford, Ill. Among the many special items listed in the table of contents are Resistance Bulbs and Wells, Radiation Detector, Special Thermocouples for Plastic Injection and Extrusion Machines, and a Molten Metal Thermocouple for Ferrous Metals. Copies of the Wheelco Data Book and Catalogue, Bulletin *TC 9*, are available upon request to Wheelco Instruments Division, Barber-Colman Company, Rockford, Ill.

Nickel Alloy Steel Castings. The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y., has issued a 32-page bulletin which contains data on properties and applications of cast nickel steel classified by industrial fields. Advantages and recommended specifications and compositions for typical service applications are given. The bulletin, entitled "Nickel Alloy Steel Castings in Industry," is available from the company.

Nuclear Data, Supplement 2. Comprehensive collection of experimental values of half-lives, radiation energies, relative isotopic abundances, nuclear moments, and cross sections. Decay schemes and level diagrams are provided wherever possible. $4.25 which includes two supplements and one supplement scheduled for publication next year. 63 pages, 98 tables. Obtainable from the Government Printing Office, Washington 25, D.C.

Electrical Homes. A 28-minute full-color movie aimed at builders and home owners entitled "Better Than Kings," which is available on a loan or outright purchase basis, has been announced by the Westinghouse Electric Corporation. The film shows 12 different circuits for a 1,500-square-foot residence, 3 general circuits, and 7 appliance circuits used in modern homes. For further information, write the Better Homes Bureau, Westinghouse Electric Corporation, 401 Liberty Avenue, Box 868, Pittsburgh 30, Pa.

Electric Contacts. The properties and uses of the Gibson line of electric contacts are described in a 12-page catalogue just published by Gibson Electric Company, Pittsburgh, Pa. Discussed in the booklet are Gibson contacts manufactured from fine silver, palladium, and nickel; silver alloys, including coin silver and Gibson Silver Alloys; and many powdered metal compositions designated as Gibsiloys. An outstanding feature of the booklet is an outline showing best Gibson contacts for various applications. The catalogue is available free from Gibson Electric Company, 8348 Frankstown Avenue, Pittsburgh 21, Pa. Inquirers should ask for Catalogue *C-520*.